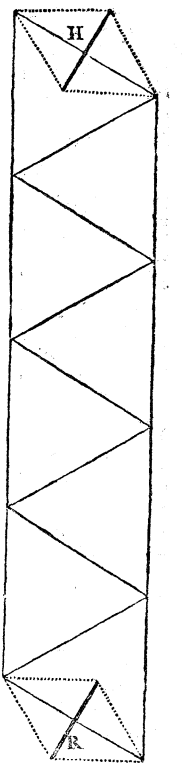
XIX. *An Account of the Mode propoſed to be followed in determining the relative Situation of the Royal Obſervatories of* Greenwich *and* Paris. *By Major-General* William Roy, *F. R. S. and A. S.*

Read February 22, 1787.

TWO years have nearly elapſed ſince an account of the meaſurement of a baſe on Hounſlow-Heath was laid before the Royal Society, being the firſt part of an operation ordered by his Majeſty to be executed for the immediate purpoſe of aſcertaining the relative ſituations of the Royal Obſervatories of Greenwich and Paris; but whoſe chief and ultimate object has always been conſidered of a ſtill more important nature, namely, the laying the foundation of a general ſurvey of the Britiſh Iſlands.

When the operation commenced in 1784, it was not doubted, that in 1786, at lateſt, we ſhould have been able to have proceeded with the ſeries of triangles from Hounſlow-Heath to the neighbourhood of Dover; but the contrivance and conſtruction of an inſtrument, new of its kind, propoſed to be made uſe of, and more particularly the nicety of its diviſion, whereby it is hoped the angles may be determined to a degree of preciſion hitherto unexampled, have required much more time than Mr.

RAMSDEN himſelf at firſt imagined. Without meaning to diſappoint, this ingenious artiſt was perhaps in the outſet too remiſs and dilatory, and accidents having happened when the workmanſhip was already far advanced, which he could not foreſee or prevent, the execution has thereby been greatly retarded. However, ſince the inſtrument may at preſent be conſidered as nearly finiſhed (ſuch parts as yet remain to be perfected being only of the ſmaller kind), we may fairly conclude, that early in the enſuing ſummer, or as ſoon as the weather in this country will permit, the trigonometrical operation may be begun. In this ſtate of things, I have therefore judged that it might be proper to lay before the Society a ſhort ſketch of the mode which is propoſed to be followed in fulfilling his Majeſty's commands, accompanied by a very ſlight general map of the country, only collected from the common ſurveys, but ſtill ſufficient to ſhew nearly the diſpoſition of the triangles that will be made uſe of in forming the junctions between the meridians of the two Obſervatories. In this buſineſs it will be underſtood, that I mean to adhere to ſuch principles as have been univerſally received and admitted as juſt.



In every ſeries of triangles where each angle is to be actually obſerved with the ſame inſtrument, they ſhould, as near as the circumſtances will permit, be equilateral: for were it poſſible to chooſe the ſtations in ſuch a manner as that each angle ſhould be exactly 60 degrees, the half number of triangles in the ſeries, multiplied by the length of one ſide, would, as in the annexed figure, give at once the total diſtance; not only the ſides of the

the ſcale or ladder would be perfectly parallel, but the diagonal ſteps, marking the progreſs from one extremity to the other, would be alternately ſo throughout the whole length. The firſt ſide is ſuppoſed to be found by the meaſurement of a baſe H, of about half its length; and the laſt ſide to be verified by ſuch another baſe R at the oppoſite extremity.

In any particular caſe, where only two angles of a triangle can be actually obſerved, theſe ſhould be as near as poſſible each 45 degrees. At any rate their ſum ſhould not differ much from 90°; for the leſs the computed angle differs from 90°, the leſs chance there will be of any conſiderable error in the interſection.

Romney-Marſh, from its levelneſs, as well as other advantageous circumſtances attending its ſituation, which the bare inſpection of the map will render obvious, ſeeming to me to afford the beſt baſe of verification for the laſt triangle, I have given the ſeries the ſhorteſt direction from Hounſlow-Heath to that part of Kent. The right hand ſtations occupy in general the heights which extend acroſs the Wealds. Thoſe on the left are placed on the great range of chalk hills, which end, on our ſide of the Channel, between Folkſtone and Walmer-Caſtle, and re-commence on the oppoſite ſide between Cape Blancnez and Calais.

It will be perceived, that I do not mean to make St. Paul's a ſtation in the ſuite; becauſe in that caſe Harrow and Hampſtead muſt likewiſe have been made uſe of, all three extremely inconvenient for the reception of the great inſtrument. Beſides, Greenwich Obſervatory being hidden from the country to the ſouth-weſt by the Norwood heights, and from that to the ſouth-eaſt by Shooter's-Hill, after having made the detour of Harrow and Hampſtead, and come acroſs the ſmoke of the Capital,

Capital, we ſhould ſtill have been obliged to make uſe of the two ſtations of Norwood and Shooter's-hill, without procuring ſo good an interſection of Bottle-hill, called in the common maps (I believe erroneouſly) Botley-hill, as is obtained by means of the ſtation at the Hundred-acre-houſe. But although none of the ſtations of the ſeries actually fall within London, nevertheleſs, from thoſe in its vicinity, *viz.* the Pagoda, Norwood, Greenwich Obſervatory, and Shooter's-hill, we ſhall equally have it in our power to determine accurately the ſituations of Harrow, Hampſtead, and St. Paul's, as well as many other chief ſteeples within the limits of the Capital.

Another principle I have endeavoured to adhere to, in the diſpoſition of the triangles, is this, that, after having obtained ſides in length from 12 to 18 miles, I continue them at that length as much as the circumſtances will permit; for, if they came to be reduced conſiderably below that extent, the obvious advantages of a long baſe at the outſet would be loſt, by the ſubſequent contraction towards the cloſe of the operation.

The tower of Tenterden church, being a very conſpicuous object, may be ſeen every where from the ſummit of the chalk hills, as far weſt as the river Medway. It likewiſe may be ſeen from the eaſtern extremity of the ſecond baſe, whereby the laſt triangle, *Tenterden*, *Lid*, *Allington Knoll*, is propoſed to be verified. This knoll is itſelf a very remarkable object, more acceſſible, and in other reſpects more proper too for the purpoſe of a ſtation than Lymne church ſteeple, which I had at one time thoughts of occupying. The high ground which ſeparates Romney-marſh from the Wealds of Kent, paſſes immediately behind *Ruckinge*, that is to ſay, to the north-weſtward of it, and may therefore probably prevent the top of the chalk hills from being ſeen from the weſt end of the baſe

of verification; but if *Tatterlees-Barn**, or any other point on the range near it, can be ſeen from Ruckinge, then the ſtation on the knoll, as well as that at Lymne, will become equally unneceſſary, and the triangle of verification will become *Tenterden*, *Lid*, *Tatterlees*.

It will be perceived, that I propoſe to have a ſtation on *Fairlight Head*, a land of conſiderable height, from whence there is a good view of the coaſt of France near Boulogne. From this point and Tatterlees, with the help of the Indian lights, I have no doubt of obtaining a fine interſection of the ſignal of the *Boulemberg*, a hill of ſome note behind the town of Boulogne, and one of the ſtations made uſe of by the French Academicians in the execution of their triangles. The advantages of obtaining a triangle of this magnitude, whoſe ſides are reſpectively in length about 45, 36, and 25 miles, are too obvious to require any comment.

The high chalk cliffs near Folkſtone prevent *Dover Caſtle* from being ſeen from Lid, or any where in the plain of Romney-marſh. Hence it will become neceſſary to form two ſmall triangles to the northward of Tatterlees, in order to obtain an interſection of one of the turrets of the keep of that caſtle. Of the center of the keep, it will be perceived, by the ſtrong dotted lines, that the French Academicians have procured, from their ſtations at *Calais*, *Blancnez*, and *Audinghen*, an acute interſection *(de la Groſſe Tour de Douvres)* making in the whole an angle of 28° 16′ 20″.

The points which are obviouſly the beſt for connecting our triangles with thoſe of our neighbours, are the Boulemberg, Blancnez, and Calais, provided we could by any means obtain

* Tatterlees Barn, in PACKE's Map of Eaſt Kent, on the ſummit of the chalk hills, 727 feet above the ſea.

as

as good an interſection of the laſt as we are certain of getting of the two firſt; but the breadth of the range of chalk hills being little different on our ſide from what it is on theirs, by confining ourſelves to ſuch a baſe as they will afford us, we cannot any way obtain an interſected angle at Calais greater than about 29° or 30°.

Thinking that poſſibly from St. Peter's church in the iſle of Thanet the tower of *Notre Dame* at Calais may be ſeen, I have extended dotted triangles into that part of Kent; becauſe, if the united heights ſhould not be ſufficient to raiſe the top of the tower above the curvature of the ſea, which is the only thing to be doubted, we are always certain, that the ſignal of *Blancnez* may, by means of the Indian lights, be eaſily ſeen, ſince the whole range of chalk hills behind Calais are diſcovered with the naked eye from the iſle of Thanet, when the weather is tolerably clear.

Having in this manner aſcertained the relative ſituations, with regard to the coaſt of England, of three points on the coaſt of France, forming a triangle whoſe ſides and angles we already know from their trigonometrical operations, we ſhall in like manner be enabled to determine the ſituation of the point M near Dunkirk, where the meridian of the Royal Obſervatory of Paris interſects a line drawn from the great tower of Dunkirk to that of *N. D.* at Calais. (See Tab. IX.) The diſtance MP, on the meridian of Paris, will then be had; and that being added to 133417 fathoms, the diſtance of M northward from the Royal Obſervatory, we ſhall have the total terreſtrial arc, comprehended between the parallels of the two Obſervatories, anſwering to an arc in the heavens of 2° 38′ 26″, or a difference of latitude between 51° 28′ 40″ and 48° 50′ 14″.

In like manner the diſtance from Greenwich to P, on the parallel of Greenwich, will then be readily computed, anſwering to the difference of longitude between the two Obſervatories; which, as far as can be judged from the map of Kent, corrected for the error in the direction of its meridian, amounts to about 2° 20′ 20″, ſuppoſing always that no uncertainty remains with regard to the poſition of the point M. But here ſome remarks become neceſſary, which may probably ſuggeſt to the Academy of Sciences, that a further inveſtigation of this matter may be needful on their part.

By referring to the 57th page of the firſt part of M. Cassini's Book (*La Méridienne vérifiée*), it will be ſeen, that Dunkirk, by one ſeries of triangles, is eaſtward from the meridian of Paris 1426.53, and by another 1414.29 toiſes, whereof the mean is 1420.41, equal to 1514 fathoms. This difference of 6½ fathoms, or little more than half a ſecond of longitude between the mean and extreme places of M, is certainly very inconſiderable. But in the 60th page, where, in verifying the meridian of Paris, by the compariſon of the angle that *Broulezele* makes with the meridian of Dunkirk, and the angle of convergence of one meridian to the other, a difference of 21 ſeconds between 10° 16′ 13″ and 10° 16′ 34″, is alledged to be almoſt inſenſible, we do not think to be a concluſion ſo unexceptionable. This, however, is not the only cauſe of uncertainty with regard to the juſt poſition of the point M: one of more importance ariſes, from the difference that is found by two ſets of triangles in the angle of interſection of the meridian of Paris, with a line drawn through M from the tower of Dunkirk to that of Calais.

Thus, by p. 53. and 56. of the firſt part of M. Cassini's book, Dunkirk being the ſtation, Broulezele makes an angle with

with the meridian of 10° 18′ 25″ towards the ſouth-weſt: and the angle between Broulezele and Hondſcote being 78° 11′ 42″, their difference 67° 53′ 17″ is the angle that Hondſcote is ſouth-eaſt from the meridian; wherefore the complement of this laſt angle to 180°, *viz.* 112° 6′ 43″ is the angle that Hondſcote makes with the meridian of Dunkirk produced northward. By p. 166. of the ſecond part, Dunkirk being the ſtation, the angle between Hondſcote and Mont-Caſſel is ſhewn to be 51° 7′ 15″; that between Mont-Caſſel and Watten 42° 6′ 35″; and by p. 167. that between Watten and Calais is 51° 40′ 20″. The ſum of theſe three angles is 144° 54′ 10″, from which deducting 67° 53′ 17″ the angle that Hondſcote is ſouth-eaſtward from the meridian, there remain 77° 0′ 53″ for the angle of Calais ſouth-weſtward from it; and the complement of this angle to 180°, *viz.* 102° 59′ 7″, becomes the angle that the meridian of Dunkirk produced northward makes with a line drawn through M to Calais: to which laſt adding the angle of convergence of one meridian to the other 1′ 50″½, correſponding to the diſtance of 1514 fathoms, equal to 1′ 29″½ of a great circle, we ſhall have 103° 0′ 57″½ for the angle which the meridian of Paris produced northward from M makes with the line joining Dunkirk and Calais.

Again, by p. 63. of the third part of M. CASSINI's book, Dunkirk being the ſtation, the angle that Gravelines makes with the meridian ſouth-weſtward is 72° 11′ 48″; and by p. 12. of the ſaid third part, the angle between Watten and *N. D.* Calais is 51° 39′ 50″: alſo that between Gravelines and Calais is 56° 42′ 0″. Now the difference between theſe two laſt 4° 47′ 50″ being added to 72° 11′ 48″, we ſhall have 76° 59′ 38″. and its complement 103° 0′ 22″, for the angles that the meridian of Dunkirk makes with the line drawn from thence through the point M to Calais: to which laſt angle adding

the former convergence $1' 50''\frac{1}{2}$, we have $103° 2' 12''\frac{1}{2}$ for the angle that the meridian of Paris produced northward from M makes with the ſaid line; but by the former ſet of angles it was found to be only $103° 0' 57''\frac{1}{2}$, wherefore the difference is $1' 15''$.

From M. CASSINI's book it appears, that Dunkirk is north from Paris 125515.25 toiſes, which make 133768 fathoms; and the point M being ſouth from the tower of Dunkirk 351 fathoms, there remains for the diſtance of M northward from the Royal Obſervatory 133417 fathoms. Now, with this diſtance as radius, the value of an angle of $1' 15''$ is $48\frac{1}{2}$ fathoms, equal to $4'' 34'''$ of longitude. Thus the point M, inſtead of being weſtward from Dunkirk 1514 fathoms, will, by the laſt ſet of angles, only be removed from it $1465\frac{1}{2}$ fathoms: wherefore the difference between the mean and extreme places of M, in this way of conſidering it, will amount to $24\frac{1}{4}$ fathoms, about four times as much as that reſulting from the compariſon ſtated in the 57th page. In the parallel of Greenwich the extreme difference will amount to 58.4 fathoms, or about $5\frac{1}{2}$ ſeconds of longitude, not much more than one-third part of a ſecond of time.

In this ſort of uncertainty, with regard to the preciſe point of interſection of the meridian of the Royal Obſervatory of Paris with the line joining Dunkirk and Calais, the only thing that can be done on our part, is to conſider the mean poſition of M as juſt, that is to ſay, to ſuppoſe it to be 1514 fathoms weſtward from the great tower of Dunkirk, and having connected it with the Britiſh triangles, to ſhew then what angle its meridian will make with the line drawn from Dunkirk to Calais.

Compariſon

Compariſon of the celeſtial arc of the meridian, comprehended between the parallels of Greenwich *and* Perpignan, *with the correſponding portions, meaſured and computed, of the terreſtrial arc of the ſaid meridian, between* M *and* Perpignan.

In the conſideration of this matter it is to be obſerved, that M. CASSINI has divided the celeſtial arc between the parallel of Dunkirk, or, which is the ſame thing, between the parallel of M and Perpignan, into four principal ſections; *viz.* that from M to Paris, from Paris to Bourges, from Bourges to Rodés, and from Rodés to Perpignan; aſſigning to each ſection the meaſured portion of the correſponding terreſtrial arc, reſulting from the triangles of the meridian.

	°	′	″	‴
By pages 110, 111, 112, of the firſt part of the book it appears, from the mean obſerved zenith diſtances of four ſtars, that the arc of the heavens, between the parallels of Dunkirk and Perpignan, contains – – – – –	8	20	2	26
And from the mean of the obſervations of a like number of ſtars, the parallel of Rodés is diſtant from that of Dunkirk, –	6	50	51	14
Wherefore Rodés is north from Perpignan –	1	39	11	12
Bourges, by the mean zenith diſtances of two ſtars, is ſouth from Dunkirk, – – – – –	3	56	59	55
Wherefore Bourges is north from Perpignan, –	4	23	2	31
And by another mean, in p. 112. it is – –	4	23	2	35
The mean of which two means gives for the diſtance of their parallels, – – – – –	4	23	2	33

	°	′	″	‴
Perpignan is ſouth from the Royal Obſervatory at Paris, by the mean zenith diſtances of four ſtars, – –	6	8	11	52
Hence Paris is ſouth from Dunkirk – –	2	11	50	34
Rodés is ſouth from Paris, by the mean zenith diſtances of two ſtars – – – – –	4	28	59	45
Hence Perpignan is ſouth from Rodés, – –	1	39	12	7
And by a former reſult it was found to be, – –	1	39	11	12
Hence the mean of the two means gives, for the diſtance of the parallels of Rodés and Perpignan, – – –	1	39	11	28

The tower of the great church at Dunkirk is northward from what was the ſtation of the ſector $84\frac{1}{4}$ toiſes, equal to 89.8 fathoms, which correſpond to an arc in the heavens of –	0	0	5	19
Wherefore the tower is north from Paris, – –	2	11	55	53
But the point M is ſouth from the tower 351 fathoms, which anſwer to an arc in the heavens of – – –	0	0	20	45
Hence the point M is northward from the Royal Obſervatory at Paris, – – – – –	2	11	35	8

Now, from theſe *data*, together with the latitude of the Royal Obſervatory at Greenwich 51° 28′ 40″, and that of Paris 48° 50′ 14″, we ſhall have the latitudes of the ſeveral ſtations between Greenwich and Perpignan, with their differences, or the celeſtial arcs comprehended between them, as underneath.

Stations.	Latitudes.				Diff. or celeſtial arcs.			
	°	′	″	‴	°	′	″	‴
Greenwich Royal Obſervatory, –	51	28	40		0	26	50	52
Point M near Dunkirk, – –	51	1	49	8				
Paris Royal Obſervatory, – –	48	50	14		2	11	35	8
Bourges, – –	47	5	4	41	1	45	9	19
Rodés – – –	44	21	13	36	2	43	51	5
Perpignan *(St. Jaumes)* -	42	42	2	8	1	39	11	28

This latitude of Perpignan 42° 42′ 2″ 8‴ is what reſults from the immediate compariſon of the lengths of the celeſtial arcs,

arcs, as determined by the zenith diſtances of ſtars, taken with a ſector of ſix feet radius, and where the obſervations are ſo nearly conſiſtent among themſelves, as to leave little doubt of their accuracy; but in the 290th page of M. CASSINI's book, ſo often quoted, as well as in the 170th page of his *Deſcription Géographique de la France*, publiſhed in 1783, the latitude of Perpignan is given 42° 41′ 55″, which is 7″ 8‴ leſs than that deduced from the obſervations, without any reaſon that I can perceive being aſſigned for the reduction.

Perpignan, the ſouthernmoſt ſtation of the meridian line extending from Dunkirk through the whole kingdom of France, is ſituated at no great diſtance from the bottom of the Pyrenean mountains, where that lofty range ends at the Mediterranean ſea. M. DE LA CAILLE was of opinion, that the plummet of the ſector muſt have been affected by the attraction which it would ſuffer from that cauſe; a ſuppoſition which, nevertheleſs, has been doubted, ſince the obſervations made in this country on the attraction of *Schehallion*: for by theſe it appeared, that the effect, although ſenſible, was but ſmall, even when the ſector was placed as near as poſſible to the oppoſite ſides of the mountain. It is indeed true, that the *Canigou*, the higheſt of the Pyrenean range, being ſituated obliquely to the meridian, and at a conſiderable diſtance from Perpignan, would not probably occaſion much deviation in the plummet; yet, on the other hand, when we compare the very trifling quantity of matter in Schehallion with the immenſity of the maſs in the Pyrenees, in the direction of the meridian, I cannot help being of M. DE LA CAILLE's opinion, that the plummet of the ſector would be ſenſibly affected, that is to ſay, it would be drawn to the ſouthward out of its perpendicular direction, and would thereby give the zenith diſtance of the

pole,

pole, or any other northern ſtar, too little, and conſequently a latitude too great. Until triangles ſhall have been extended beyond the Pyrenees, and the ſector placed on the ſouth ſide of the range, the quantity of this attraction (by its double or counter-effect) cannot poſſibly be aſcertained. I will, however, only ſuppoſe it to have been 10″ 8‴ to be deducted from the latitude of Perpignan, which will then become 42° 41′ 52″, only three ſeconds leſs than that aſſigned to it in M. CASSINI's two books before mentioned. Thus the arc between Rodés and Perpignan will be 1° 39′ 21″ 36‴, and the total celeſtial arc between Greenwich and Perpignan will be 8° 46′ 48″, as may be ſeen by attending to the four columns towards the left-hand of the annexed table of compariſon.

With regard to the correſponding terreſtrial arc, under which head are arranged the eleven columns towards the right-hand of the table, it is to be obſerved, that various meaſurements have at different times been made in different latitudes of the lengths of the degrees of the meridian, for the purpoſe of obtaining, within certain limits at leaſt, the true figure and dimenſions of the earth. The moſt eſſential operations of this ſort, as having been executed with moſt care, with the beſt inſtruments, and at the greateſt diſtances from each other, have all been done within theſe laſt forty or fifty years; namely, in Peru under the equator, in middle latitudes in France and Italy, and in Lapland near the polar circle. The attraction of mountains, and unavoidable errors in the execution, will ever prevent juſt concluſions from being drawn from the compariſon of meaſurements made too near each other. Theſe laſt will always be found to differ more or leſs among themſelves. Sometimes even the reſults may become abſurd or contradictory. In caſes of this ſort, a mean of ſeveral ſhould no doubt be

taken for a mean latitude, unleſs there ſhould be ſufficient grounds for rejecting any from the number, as differing too much from the others. Hence it is, that philoſophers are not yet agreed in opinion with regard to the figure of the earth; ſome contending, that it has no regular figure, that is to ſay, not ſuch as would be generated by the revolution of a curve around its axis. Others have ſuppoſed it to be an ellipſoid; regular, if both polar ſides ſhould have the ſame degree of flatneſs; but irregular, if one ſhould be flatter than the other. And, laſtly, ſome ſuppoſe it to be a ſpheroid differing from the ellipſoid, but ſuch as would be formed, nevertheleſs, by the revolution of a curve around its axis; although in this caſe too one polar ſide may not be ſimilar to, but more or leſs oblate than the other.

In order, therefore, to put this matter in its true light, and to enable every one to judge, by ſimple inſpection only, which of the theories agrees beſt with actual meaſurement, I have computed on ten different *hypotheſes*, and arranged in their order, the lengths of the arc between Greenwich and Perpignan; as alſo ſome other chief properties of each figure, which laſt fill up the ſpace towards the bottom of the table. This mode of collecting the reſults ſeemed to me to be the moſt diſtinct that could be followed, to avoid that perplexity which muſt for ever occur in referring back to, and comparing, many numbers together, computed on different ſyſtems, when the whole are not placed before the eye at once.

The firſt of the eleven columns, or that which comes next to the celeſtial arc, contains the meaſured portions of the correſponding terreſtrial arc, as far as they have yet been executed. The blanks at top cannot be ſupplied, until we ſhall

have determined the length MP, in the map, being the ſpace comprehended between the parallels of M and Greenwich.

In the ſecond column are arranged the computed dimenſions appertaining to the earth as a ſphere, ſuppoſing its ſemi-diameter to be a mean between the longeſt and ſhorteſt of M. Bouguer's ſecond ſpheroid. It is from the magnitude of this ſphere that I compute the degrees of a great circle for the ſides of ſpherical triangles. By adverting to the errors or differences between the meaſurement and computation, in their reſpective places, it will obviouſly appear that the earth differs very conſiderably from a ſphere: for although the arc M Perpignan of $8°\frac{1}{3}$ only exceeds the truth by 609 fathoms; yet an arc of equal length at the equator, *viz.* $8°.33 \times 374.6$, would give an exceſs of 3120 fathoms; and at the polar circle $8°33 \times 335.2$ would give a defect of 2792 fathoms.

After the ſphere follow ſeven ellipſoids of different degrees of oblateneſs, from the firſt, whoſe ſemi-diameters have to each other the ratio of 179.047 to 178.047, to the ſeventh, where it is only that of 540 to 539. On the principles which have ſerved as the foundation of the firſt and ſecond, it will be neceſſary to make ſome remarks; but as to the others, a few words will ſuffice for each.

With regard to the firſt ellipſoid, ſuppoſing the earth to be homogeneous, it is well known, that the ratio of its ſemi-diameters may be found, by comparing with each other the lengths of the pendulums that vibrate ſeconds in different latitudes; which lengths are deduced from the ſeconds of acceleration, that the pendulum, ſo adjuſted, and unalterably fixed as to length, at the equator, would perform in 24 hours, on being ſucceſſively tranſported to different latitudes, as far as the pole, where the force of gravity being the greateſt, the acceleration would likewiſe be the greateſt. The calcu-

lations for this purpoſe were firſt made ſoon after * Lord MULGRAVE's return from his Voyage towards the North Pole in 1773.

* The moſt northern experiments hitherto made with the pendulum, are thoſe at Spitzbergen, in latitude 79° 50′, whereof an account has been given in the Voyage towards the North Pole in 1773. The machine made uſe of on that occaſion belonged originally to the celebrated watch-maker, Mr. GRAHAM, and was lent for the purpoſe by its preſent proprietor, Mr. CUMMING, who has ſince obligingly permitted it to remain for ſeveral years, at two different times, in my poſſeſſion, where it now is. Soon after the return from Spitzbergen, I aſcertained its rate of going by my obſervatory clock, for a great while together, in very different temperatures; and thereby found, that the variation from heat and cold, namely, $\frac{6}{10}$ths of a ſecond for each degree of FAHRENHEIT, was conſiderably more than had been allowed for it, in determining the acceleration from London to Spitzbergen. About this time likewiſe, Dr HORSLEY diſcovered that an error had been committed by the aſtronomer (the late Mr. ISRAEL LYONS) employed by the Board of Longitude on that Voyage, in calculating the ſpherical triangle for the correction of the time between the 16th and 17th of July, on account of the obliquity of the tranſit-inſtrument. From Dr. HORSLEY's printed letter on this ſubject in 1774, it appears, that the difference from that cauſe amounted to 37 ſeconds in time, as given by the obſervation with the inſtrument and by the watch. And ſince there was reaſon to ſuſpect, that the teleſcope had by accident been moved (one could not tell how much), it was judged ſafeſt to adhere to the acceleration 71″.08 as given by the watch. The correction for the greater contraction of the ſteel rod, I found to be 2″.58 to be ſubtracted, wherefore the acceleration from London to Spitzbergen became 68″.5, and that from the equator to London being 156″, the total acceleration from the equator to Spitzbergen conſequently was 224″.5. Now, ſuppoſing the length of the pendulum at the equator to be, as M. BOUGUER made it, juſt 38.9949 inches, we ſhall have its length at Spitzbergen 39.1978 inches; and thence the ratio of the ſemi-diameters of the earth, conſidered as an homogeneous ellipſoid, will be that of 193.1 to 192.1, inſtead of 183.7 to 182.7, which the acceleration 72″.7 uncorrected would have given. And here it ſeems neceſſary to mention ſome other miſtakes of computation, inadvertently fallen into by the aſtronomer, in deducing the ratios of the ſemi-diameters of the earth, as ſtated in the 179th page of the Voyage to the North Pole, not hitherto noticed that I know of.

1773. I am aware that experiments with the pendulum have not yet been made with that accuracy that the delicacy of their nature

With the accelerations, indicated in that page as arifing from different experiments, or depending on the fyftems of different philofophers, the length of the Spitzbergen pendulum, and confequently the ratios, fhould have ftood as in the annexed table, with which it will be perceived they differ very confiderably. Sir Isaac Newton's ratio is placed laft, as probably differing moft from the truth.

Experiments.	Acceleration			Length of the Spitzberg. pendulum.	Ratio of the femi diameters of the earth.
	From the equator to London.	From London to Spitzberg.	Total.		
		//	///	In.	
Said to be, but erroneoufly, Sir I. Newton's	156″	+66.9	222.9	39.1964	194.5 to 193.5
Mr. Campbell's		+76.6	232.6	39.2052	186.5 to 185.5
M. Maupertuis's		+86.5	242.5	39.2141	178.8 to 177.8
Ld Mulgrave's correct.		+68.5	224.5	39.1978	193.1 to 192.1
Sir Isaac Newton's		+32.4	188.4	39.1652	230. to 229.

In this manner the lengths of the pendulum having been found for all the latitudes where the beft or moft confiftent experiments had been made on its acceleration, and thefe lengths having been fucceffively compared with each other from Spitzbergen to the equator, 119 refults in the whole were produced. But as this number comprehended the comparifons of thofe at the Cape of Good Hope and the Ifle of France, both in fouth latitude, thefe being thrown out, as well as the Porto Bello pendulum, and fome few others more irregular than the reft, there remained at laft 75 refults, the arithmetical mean of which gave the ratio 179.047 to 178.047, as mentioned in the text.

In cafe Mr. Cumming's machine fhould at any time hereafter be employed in the fame fort of experiments, it may be proper to obferve, that the diameter of the brafs ball is 3.906 inches, and its weight 63726 Troy grains. The weight of its bulk of mercury is 106980 Troy grains. Hence the weight of mercury is to the weight of this ball of brafs, in air of the heat of 62° of Fahrenheit, as 1.678752 to 1; and the weight of this brafs to air is as 7673 to 1. The experiments for this purpofe, in which Dr. George Fordyce affifted, were made in the houfe of Mr. Alchorne, at his Majefty's Mint in the Tower, on the

nature ſeems to require, and which at ſome future period ſhould, and probably will, be undertaken on a more extended plan, with the very beſt machines that can be conſtructed for the purpoſe. Many ages may elapſe before meaſurements of any conſiderable portion of the ſurface of the earth can be made in very high ſouthern latitudes, ſo as to determine, with any tolerable degree of exactneſs, whether the ſouthern ſemi-ſpheroid be ſimilar to the northern, ſuppoſing both to be figures of revolution. But by good experiments with the pendulum alone, eaſily repeated in all latitudes, the ratio of the ſemi-diameter of the equator to the ſemi-axis on both ſides may be readily obtained. In the mean time I thought it might be uſeful to ſhew the reſult of a compariſon of the moſt conſiſtent experiments of that ſort, that have hitherto been made in different latitudes, after having applied to thoſe at Spitzbergen certain corrections, which ſeemed neceſſary, as further explained in the note. Thus it appears, that the arithmetical mean of 75 compariſons between Spitzbergen and the equator gives the

the 8th of April and 6th of June, 1776; and the beam made uſe of, with 15 lbs. weight in each ſcale, was true to three grains.

The machine, in its preſent ſtate, although better fitted for experiments than it was originally, ſince it has a wheel added, whereby it regiſters its own time, and now goes for 12 hours without winding up, is no longer the ſame that performed at Spitzbergen: for in the interim of the two times it has been in my poſſeſſion, the ſteel rod having by accident been broken, Mr. CUMMING ſubſtituted another, as like to the former as poſſible with regard to ſize, but which will, in all probability, be ſuſceptible of a different expanſion and contraction from the effects of heat and cold. In the application of the machine, I have uſually loaded the top of it with about 24 lbs. weight of lead, in order to render the center of ſuſpenſion as little liable to motion as poſſible: yet, notwithſtanding this precaution, a pointed plummet, ſuſpended to the top of the frame, has a ſmall degree of counter-vibration to that of the ball, which no doubt muſt produce ſome effect.

ratio

ratio of the ſemi-diameters formerly mentioned 179.047 to 178.047. On this hypotheſis the arc MP ſhould contain 27350 fathoms. The error on the total arc M Perpignan amounts to 2078 fathoms. M. Bouguer's degree at the equator being adhered to, the 45th of latitude will exceed the truth 216, and that at the equator 148 fathoms,

The ratio of the ſemi-diameters of the ſecond ellipſoid, which comes now to be ſpoken of, has been obtained by the compariſon of ſuch meaſured lengths of the degrees of the meridian in different latitudes, as have been found to be moſt conſiſtent with each other. Our countryman, Mr. Norwood, was the firſt, of late times, who made any attempt of this ſort. But the meaſurement, executed by him in the year 1633, between London and York, has no pretence to exactneſs, ſince he himſelf tells us, *that when he did not meaſure, he paced!* Beſides, his degree is as great, or even greater, than that in Lapland; and theſe are ſurely ſufficient reaſons for rejecting it from the compariſon. The degree meaſured by M. Liesganig in latitude 45° 57′, in that part of Poland lately fallen to the ſhare of the Emperor and annexed to Hungary, being ſo much ſhorter than degrees to the ſouthward of it, gives grounds to ſuſpect, that ſome error had crept into that operation, or that the plummet had been affected by the attraction of neighbouring mountains, and therefore is not made uſe of on the preſent occaſion. M. de la Caille's degree at the Cape of Good Hope, being in ſouth latitude, and ſo much greater than thoſe of the ſame height in northern latitudes, is improper likewiſe to be brought into the compariſon, leſt the difference may have ariſen from a diſſimilarity in the two polar ſides of the ellipſoid. The degree meaſured in the north of France, compared with that in Auſtria, coming out abſurd,

abſurd, it has been judged beſt to take a mean between them for a mean latitude. In like manner the latitudes of the two Italian degrees differing but little from each other, a mean length has been taken between them for a mean latitude. Accordingly the latitudes and the meaſured lengths of the degrees which, in the ſecond ellipſoid, have been compared together, will appear as underneath:

Obſervers names.	Countries.	Latitudes.		Meaſured lengths.	
		°	′		
Bouguer,	Peru, – –	0	0	–	60484.5
Mason and Dixon,	Maryland, –	39	12	–	60628.5
Boscowich,	Italy, –	43° 0′	43 52	60725.5	60773.4
Beccaria,	Piedmont –	44 44		60821.3	
Caſſini, &c.	Middle of France,	–	45 0	–	60777.6
Liesganig,	Auſtria, –	48 43	49 3	60839.4	60833.0
Caſſini, &c.	North of France, –	49 23		60826.6	
Maupertuis, &c.	Lapland, –		66 20	–	61194.3

Now theſe ſix degrees, being ſucceſſively compared with each other, fifteen reſults are thereby obtained, whereof the arithmetical mean gives for the ratio of the ſemi-diameters of the ellipſoid that of 192.483 to 191.483. By adverting to the table, it will further appear, that the arc MP ſhould be in length 27331 fathoms. The arc M Perpignan exceeds the truth 1758, the 45th of latitude 180, and that at the polar circle near 88 fathoms.

The ratio of the ſemi-diameters of the third ellipſoid 216.06 to 215.06 is obtained by adhering to the meaſured lengths of the degrees at the equator and polar circle. According to this hypotheſis the arc MP ſhould contain 27301 fathoms. The arc M Perpignan exceeds the truth 1288, and that at the 45th of latitude more than 128 fathoms.

The

The ratio of the ſemi-diameters of the fourth ellipſoid 222.55 to 221.55 is the ſame, as may be ſeen by referring to the table, with that aſſigned by M. BOUGUER to his firſt ſpheroid, where the increments to the degrees of the meridian above that at the equator are as the ſecond power or ſquares of the ſines of the latitudes. It was intended chiefly to ſhew how ſmall the difference is between the magnitudes and nature of the curves of the two figures. The arc MP ſhould contain 27294 fathoms. The arc M Perpignan errs in exceſs 1177 fathoms. The 45th degree exceeds the truth 116 fathoms; and that at the polar circle falls ſhort of the meaſured length 21 fathoms: M. BOUGUER's degree at the equator being adhered to as the ſtandard.

The ratio of the ſemi-diameters of the fifth ellipſoid, 230 to 229, is that aſſigned to the earth by Sir ISAAC NEWTON. On this hypotheſis the arc MP ſhould contain 27241 fathoms. The arc M Perpignan only exceeds the truth 202 fathoms, becauſe the 45th degree of the meridian is here adhered to as the ſtandard length. But then the degree at the equator falls ſhort of the meaſurement 102 fathoms, and that at the polar circle 146½; wherefore, an arc of 8°⅓, in the firſt caſe, would be defective 850, and in the laſt 1220 fathoms.

The ratio of the ſemi-diameters of the ſixth ellipſoid, 310.3 to 309.3, is obtained by adhering to the meaſured lengths of the degrees at the equator and 45th of latitude. The arc MP ſhould contain 27230 fathoms. The arc M Perpignan only exceeds the truth 131 fathoms; but on this hypotheſis, the degree at the polar circle would be defective near 217 fathoms, and conſequently on 8°⅓ the error would be 1807 fathoms.

The ſeventh or laſt ellipſoid, being that of the leaſt flattening, has for the ratio of its ſemi-diameters 540 to 539. The arc MP ſhould contain 27206 fathoms. The 45th degree of latitude being adhered to as the ſtandard, the arc M Perpignan would only exceed the truth by 46 fathoms; but, on the other hand, the degree at the equator erring in exceſs 124½ fathoms, and that at the polar circle being defective near 303; therefore, in the firſt caſe, the error on 8°⅓ would be 1037, and in the laſt 2524 fathoms. Hence it is obvious, that the arcs of an ellipſoid, however great or ſmall the degree of its oblateneſs may be, will not any way correſpond with the meaſured portions of the ſurface of the earth: for if we retain the length of M. Bouguer's degree at the equator as the ſtandard, and make the ellipſoid extremely flat, as in N° 1. the figure will become too prominent in middle latitudes, that is to ſay, the curve will riſe above the real ſurface of the earth, and, in proportion to the exceſs of the radius, will always give degrees that exceed the meaſured length. On the contrary, if we give the ellipſoid a ſmall degree of flatneſs, as in N° 7. and adopt the meaſured length of the 45th degree as the ſtandard, the meaſured and computed arcs will nearly agree in middle latitudes; but at the equator the curve will riſe very conſiderably above the ſurface, and will thereby give degrees that are too great; while at the polar circle it will fall below it, and give degrees that are too little in the proportion of about 2½ to 1 compared with the error at the equator. From all which we may conclude, that the earth is not an ellipſoid.

The two columns towards the right-hand of the table, contain the arcs of two ſpheroids differing from the ellipſoid. The firſt is that adopted by M. Bouguer as his firſt hypotheſis, where the increments to the degrees of the meridian

above that at the equator follow the ratio of the ſecond power or ſquares of the ſines of the latitudes, and to which he has ſuited his firſt table of degrees, N° 32. p. 298. This ſpheroid differs but inſenſibly, as has been already mentioned, from the fourth ellipſoid. They have both the ſame ſemi-diameters; but the arcs of the ſpheroid being ſomewhat longer than thoſe of the ellipſoid, the former thereby becomes, in a trifling degree, more prominent in middle latitudes. On this hypotheſis the arc MP ſhould be in length 27295 fathoms; M Perpignan exceeds the meaſurement 1196 fathoms; and the degree at the equator being adhered to as the ſtandard, the 45th errs in exceſs 118, while that at the polar circle is defective only 20 fathoms.

The ſecond ſpheroid is that whereon M. BOUGUER founded his ſecond hypotheſis, which ſuppoſes the increments to the degrees of the meridian, above that at the equator, to follow the ratio of the fourth power or ſquared ſquares of the ſines of the latitudes, and to which he has adapted his ſecond table of degrees N° 38. p. 305. It will be perceived, that the ratio of the ſemi-diameters of this ſpheroid, *viz.* 179.4 to 178.4 differs little from that appertaining to the firſt ellipſoid; but here the curve falling conſiderably within, that is to ſay, being leſs prominent than the ellipſoid in middle latitudes, the arcs are thereby contracted in ſuch a manner as to agree within 5 fathoms with the meaſured length of the meridian of France, in an extent of about $8°\frac{1}{3}$, comprehended between M near Dunkirk, and Perpignan ſituated at the bottom of the Pyrenean mountains. By inſpection of the table it will further appear, that the errors in the ſeveral ſections of this arc are not only ſmall, but they are ſometimes *plus* and ſometimes *minus*, a never failing proof that, as far as our preſent *data* will enable

us

us to judge, the figure here aſſigned to the earth, notwithſtanding what has been alledged to the * contrary, is exceedingly near the truth. According to this hypotheſis, the diſtance MP on the meridian of Paris, which is yet to be determined by our trigonometrical operations, ſhould contain 27243 fathoms, being only 35 fathoms leſs than what is given by the mean of the ſeven different ellipſoids, a ſpace not amounting quite to $2''$ of latitude. The reſult of the meaſurement of this ſpace, anſwering to an arc in the heavens of $26'\ 50''\ 52'''$ of latitude, will be a further confirmation, or otherwiſe, of the juſtneſs of the theory. The degree at the equator being adhered to as the ſtandard, it will be ſeen from the table, that the 45th is defective 37.6, while that at the polar circle errs in exceſs 9.4 fathoms.

* Mr. J. KLOSTERMANN, Inſpector of the Corps of Pages at St. Peterſburg, in his manuſcript Memoir, ſome time ſince tranſmitted to the Royal Society, to the Academy of Sciences at Paris, and alſo to that at Gottingen, has endeavoured to ſhew, that the French trigonometrical operations are extremely erroneous. It would ſeem, nevertheleſs, that he has attempted to prove too much. He ſhould certainly have confined his criticiſm to the triangles of the meridian only, which are diſtinguiſhed from the others in M. CASSINI's book, by being printed in larger characters, without drawing concluſions from very acute angles, which, although inſerted in the general regiſter, were not made uſe of in the determination in queſtion. But as the Royal Academy of Sciences will, no doubt, vindicate the credit of their own operations, I ſhall only further remark, on the Literary News from Gottingen (*Nachricht aus den Göttingiſchen Anzeigen von gelehrten Sachen*, 117 *Stück*, 1785), which accompanied the ſaid Memoir, and where it is ſaid, "That M. BOUGUER's hypotheſis of the 4th power fell to the "ground, ſo ſoon as other degrees were meaſured than thoſe on which he had "founded it," that I confeſs myſelf to be quite of a different opinion, not doubting, that when the compariſon is fairly drawn between this and every other ſyſtem that has hitherto been ſubmitted to the conſideration of the public, M. BOUGUER's will be found to be juſtly entitled to the preference, which I have here endeavoured to give it. His works ſhew, that he was a man of very ſuperior abilities, eminent as a mathematician, and perhaps the beſt practical one that ever exiſted.

Beſides theſe two ſpheroids of M. BOUGUER, I had computed the arcs of another between the two, where the increments to the degrees of the meridian were in the ratio of the fractional power $3\frac{42}{100}$ of the ſines of the latitudes. Thus the computed agreed accurately with the meaſured dimenſions in three principal parts of the earth's circumference, namely, at the equator, 45° and 66° 20′ of latitude, at the ſame time that the arc MP contained 27257 fathoms; but the labour of computation being hereby greatly augmented, and the error on the total arc between M and Perpignan amounting to 290 fathoms in exceſs, this ſyſtem did not ſeem to me to deſerve to be put in competition with the ſimplicity of that of M. BOUGUER, who indeed, for the ſame reaſon, preferred the fourth to the fractional power $3\frac{10}{11}$ths, which he tells us was that which ſtill came nearer the truth. In ſhort, it muſt be from the reſults of future operations executed in very high latitudes, and the meaſurement of degrees of longitude on the equator, that we can hope to have ſufficient authority for any correction or a melioration of the ſyſtem of M. BOUGUER.

Differences of longitude.

Hitherto there has been no particular reference to ſome lines at the bottom of the table, containing the computed lengths of degrees of longitude on each hypotheſis, in three different latitudes, namely, the equator, 43° 32″ and 51° 28′ 40″. No meaſurements of degrees of longitude, as far as I know, have ever been executed with ſufficient care and accuracy, except that in the ſouth of France, as mentioned in the 105th and 106th pages of M. CASSINI's book, which was determined by the

the repeated exploſions of gunpowder in the open air, and found to contain 41618 toiſes, equal to 44354.4 fathoms. By attending to the table it will be ſeen, that the error in exceſs of M. BOUGUER's theory, on the length of this degree trigonometrically meaſured, amounts only to 19 fathoms, which is little more than $\frac{1}{10}$th part of a ſecond of time.

In fixed Obſervatories, where able aſtronomers have been for many years employed in repeating their obſervations of the heavenly bodies, it ſeems ſurpriſing, that any doubt ſhould remain with regard to what is called the aſtronomical difference of longitude, or, in other words, the difference of time between them; yet it has been alledged, that an uncertainty of this ſort exiſts, even with regard to the ſituation of Greenwich and Paris, which, reckoned by its extremes, extends to about 10 or 11 ſeconds, anſwering in the latitude of Greenwich to the enormous difference in ſpace of between 1600 and 1700 fathoms! But it will be conſidered as ſtill more wonderful, if between two Britiſh Obſervatories, Greenwich and Oxford, which have been long ſupplied with great and coſtly inſtruments of the very beſt kinds, there ſhould remain an uncertainty in this reſpect of 2 or 3 ſeconds of time: for in the latitude of Greenwich 3 ſeconds correſpond to 477, and in that of Oxford to 474½ fathoms. Theſe, however, are points which muſt be left to the reſpective aſtronomers to ſettle in the beſt way they can; and it is not to be doubted, that the Aſtronomer Royal will throw a new and very ſatisfactory light on the matter, in the Paper which he propoſes about this time to lay before the Royal Society, along with M. CASSINI's Memoir, which, for that purpoſe, has now been nearly two years in his poſſeſſion.

With

With regard to the trigonometrical operation (which may be conſidered as infallible, becauſe, by means of the baſe of verification, it will prove itſelf, and if ſmall errors unavoidably ariſe in the courſe of a long ſuite of triangles the maximum of theſe may be always aſcertained), I have no doubt that the diſtance between Greenwich and the point P in the map may thereby be determined to a very ſmall number of fathoms, perhaps to fifteen or ſixteen on a difference of longitude of about 2° 20′ 20″, and therefore to about $\frac{1}{20}$th part of a ſecond of time on each degree. This, for any uſeful purpoſe, will certainly be admitted to be ſufficiently near the truth, and is probably conſiderably nearer than it will be brought for many years to come, by a mean of the beſt obſervations of the heavenly bodies, if theſe ſhould be found in the preſent ſtate of the matter to leave it yet doubtful to two or three ſeconds.

The aſtronomical difference of time may likewiſe be obtained by experiments on the inſtantaneous exploſion of light; but theſe I would propoſe to be made ſubſequently to the trigonometrical operations. The ſtation of *Tatterlees*, towards the eaſtern extremity of our range of chalk hills, or ſome point near it, would ſeem to be the moſt proper for the place of exploſion, becauſe it can be ſeen from *Bottle-hill*, on the ſame range, and nearly in the meridian of Greenwich Obſervatory. It is not to be doubted, that *Tatterlees* may be ſeen from *Fienne Windmill*, or even perhaps from that of the *Brunemberg*; ſince they are both ſituations, on the continuation of the ſame range in France, the diſtance being ſhorter too, and little land, but chiefly ſea, intervening. Let us then ſuppoſe, that the two aſtronomers with their clocks and tranſit-inſtruments are poſted, one at *Bottle-hill*, and the other at the *Brunemberg*, while gunpowder is repeatedly exploded at *Tatterlees*, or while the Indian lights

lights are alternately exhibited, and again covered by an extinguiſher prepared for the purpoſe, which operation may be repeated ſeveral times the ſame evening; it is certain, that a juſt mean being taken between the inſtants ſo marked by the reſpective clocks, well regulated before-hand, the difference of time between the two extreme ſtations will thereby be obtained to a very conſiderable degree of accuracy, and probably more to be relied upon than that reſulting from the compariſon of the obſervations of the heavenly bodies.

Rockets have been propoſed by ſome to be applied in this way; but even the largeſt ſort, carrying up too ſmall a body of white light, could, I think, only be depended upon for ſhort diſtances; and ſince the actual error of obſervation would be the ſame on a ſhort as on a long diſtance, remote ſtations only ſhould be choſen for concluſive experiments of this nature. It is imagined, that by means of a balloon, a ſet of light-balls might be ſent up of ſuch a volume as to be ſeen, from their great elevation in the air, at ſtations very remote from the place of exploſion. The balloon would aſcend with a burning fuze attached to the firſt ball, and having attained the wiſhed-for height, it might be made faſt below, by means of a cord fixed to it for the purpoſe *. The firſt ball, on its exploſion, would communicate fire to the ſecond, and ſo in ſucceſſion, at intervals of time proportionable to the lengths of

* It is to be underſtood, that the practicability of faſtening the balloon to the earth by means of a rope muſt be previouſly aſcertained: for if that ſhould be found impoſſible, without the wind forcing it down again to the ground, then it muſt be ſent up detached with burning fuzes fixed to it, of ſtill greater dimenſions. By means of theſe it is imagined, that the track of the balloon in the air might be pointed out to the remote obſervers, who might perhaps be better enabled thereby to watch for and diſtinguiſh the ſucceſſive inſtants of the burſting of the white lights.

the

the fuzes. Thus 8 or 10 inſtants might be marked from the experiment of a ſingle balloon, which might then be hauled down to be reloaded for a repetition. But whatever might be the mode adopted as the beſt for conducting experiments of this nature, the obſervers muſt not only be very attentive and diligent, but alſo quick-ſighted, have their clocks nicely regulated indeed, and the trials muſt be many times repeated before the uncertainty, even in this way, which ſeems to be the beſt mode, could be reduced to leſs than $\frac{1}{20}$th part of a ſecond of time, to which it may infallibly be brought by trigonometry.

Having in this manner ſhewn what probable degree of exactneſs may be expected in the various, but uſual, ways of aſcertaining the difference of longitude between the Obſervatories of Greenwich and Paris, and compared the reſults with the uncertainty that ſeems yet to exiſt in this matter from the ſtate of aſtronomical obſervations; let us next ſee how Mr. RAMSDEN's inſtrument is likely to perform, when actually applied to the determination in queſtion, by the obſerved angle between the pole ſtar in its eaſtern or weſtern azimuth, and a very remote ſtation, whoſe diſtance from the inſtrument is known by the ſeries of triangles, and diſtinguiſhable by the Indian lights at night, for the purpoſe of this particular obſervation.

With an inſtrument, carrying teleſcopes ſo good that the pole ſtar may be ſeen in daylight, it is obvious, that the biſected angle between the ſtar in its eaſtern and weſtern azimuths will give at once the polar diſtance of the ſtar, and the true meridian of the place, as referred to any known ſtations viſible at the time of obſervation. But as cloudy weather may often prevent a complete obſervation of this ſort from being obtained, and ſince much time might be loſt in

attempting it, therefore the declination of the ſtar ſettled for any particular period being accurately known*, its apparent diſtance from the pole may, by the eſtabliſhed rules, be readily computed for any propoſed day, as well as the preciſe times of its greateſt elongations, twice in 24 hours, when in its eaſtern and weſtern azimuths, at which times it will, for ſeveral minutes, appear, as to ſenſe, ſtationary or without motion, except in altitude. Theſe are, therefore, the beſt times for taking the angle between the ſtar and any particular ſtation, ſince the obſervations may be repeated frequently in the ſpace of a few minutes, or until it ſhall be perceived that the ſtar has again approached towards the pole. Now, ſuppoſe the ſtation of the inſtrument to be at *Tatterlees*, whoſe diſtance from the perpendicular to the meridian of Greenwich, and conſequently from its parallel, is known by the trigonometrical operation. The latitude of the ſtation becomes known likewiſe; and let the co-latitude be 38° 54′ 20″. Let us likewiſe ſuppoſe the diſtance of *Bottle-hill* on one ſide to be 44100 fathoms, equal to 43′ 28″.6 of a great circle; and that of the *Brunemberg* on the other to be 38250 fathoms, equal to 37′ 42″.6 of a great circle; and further, that on theſe two ſtations the Indian lights are exhibited for the time propoſed. Now, let the angle between the meridian and *Bottle-hill*, and that between it and the *Brunemberg*, be obſerved by means of the pole ſtar corrected for its diſtance for the day; and ſuppoſe the firſt to be 75° 10′,

* Since this Paper was written, the Aſtronomer Royal has been ſo obliging as to furniſh me with the mean diſtance of the pole ſtar from the pole, as ſettled at Greenwich by eight obſervations above and nine below it, made in the year 1786; whereby it appears, that the mean diſtance, reduced to the beginning of that year, was 1° 50′ 8″.35; and the mean annual preceſſion in declination being 19″.55, conſequently, the mean diſtance for the 1ſt of January, 1787, was 1° 49′ 8″.8.

and the laſt 125° 5′; thus we ſhall have two ſpherical triangles to compute, in each of which two ſides, and the contained angle, are known, and one ſide, *viz.* the co-latitude, is common to both. Now, from theſe *data*, making uſe of the half ſum and half difference of the ſides, we ſhall have the angles in theſe two triangles as * underneath, and the angle of longitude between *Bottle-hill* and the *Brunemberg*, equal to that at the pole, will be found to be 1° 55′ 56″.1. If from this angle we deduct about 30″ or 35″, for the ſpace that the *Bottle-hill* ſeems to be to the weſtward of the meridian of Greenwich, there will then remain 1° 55′ 21″ for the eaſt longitude of the *Brunemberg*, being very nearly that expreſſed in the map of the triangles which accompanies this paper.

* Bottle-hill.	°	′	″	Brunemberg.	°	′	″
Half difference –	51	25	14.05	Half difference –	26	44	12.2
Half ſum –	52	32	25.07	Half ſum –	27	32	57.3
Angle at Bottle-hill	103	57	39.12	Angle at Brunemberg	54	17	9.5
Angle at the pole –	1	7	11.02	Angle at the pole –		48	45.1
Contained angle –	75	10	0.	Contained angle –	125	5	0.
Sum of the three angles	180	14	50.14	Sum of the three angles	180	10	54.6
Angle of convergence		52	20.88	Angle of convergence –		37	50.5
Exceſs above 180° –		14	50.14	Exceſs above 180° –		10	54.6
Angle of longitude –	1	7	11.02	Angle of longitude –		48	45.1

Sum of the two longitudes 1° 55′ 56″.12.

It is to be obſerved, that the meridians, which are all parallel to each other at the equator, on their departure from thence converge more and more as they approach towards the pole, where the angle of convergence becomes equal to the angle of longitude. It may alſo be remarked, that the angle of convergence, augmented by the exceſs of the three angles of the ſpherical triangle above 180°, is always equal to the angle of longitude, or that at the pole. And as this holds univerſally in all latitudes, it affords a ready means of proving that the computations are juſt.

As far as we are enabled to judge at preſent, from the examination of the diviſions of Mr. RAMSDEN's inſtrument, there is every reaſon to believe, that in taking angles around the horizon, the mean of ſeveral repetitions of the ſame angle, as referred to different parts of the circumference of the circle, will differ very little from the truth, ſo little indeed, that in many caſes the error will totally vaniſh. But in elevating the teleſcope towards the pole, let us ſuppoſe that an error of 5 ſeconds on each of the contained angles at *Tatterlees* has been committed; and further, that even an error of 5 ſeconds of latitude, equal to about $84\frac{1}{2}$ fathoms on the meridian, may have been fallen into, in eſtimating the co-latitude (which never can happen, but is only here admitted, to place the example in the moſt diſadvantageous circumſtances poſſible); then whoever will give themſelves the trouble to recompute the two triangles with theſe new *data*, will find the reſult in longitude not to be varied thereby, in the firſt caſe above $\frac{1}{5}$th part of a ſecond, or $\frac{1}{75}$th part of a ſecond in time; and in the laſt not quite 1 ſecond, or $\frac{1}{75}$th part of a ſecond in time. Hence I conclude, that the beſt mode of determining the differences of longitude will be by the inſtrument itſelf, applied in this way, in taking the angles between the pole ſtar and very remote ſtations, diſtinguiſhable at night by the help of the Indian lights, and whoſe diſtance is accurately known. This method will, it is true, be liable, as well as aſtronomical obſervations, to the imperfections of the inſtrument, particularly thoſe of the teleſcope, and the unavoidable error in its application; but, on the other hand, it will be entirely free from the irregularities of clocks, and the imperfections of viſion in marking the inſtantaneous exploſion of light. When both methods have been repeated a ſufficient number of times, with all

imaginable care, we ſhall then, and not till then, be able to judge to which the preference may be due. Thus five or ſix long ſtations, in or nearly in the parallel of Greenwich, ſuch, for inſtance, as that of Shooter's-hill Tower, would reach from the eaſt quite to the weſt of the iſland: and as a very conſiderable degree of conſiſtency might be expected among the reſults for equal portions of the parallel, this method ſeems to be as likely as any to furniſh *data* for determining the nature of the ſpheroid or figure of the earth.

Table of the degrees of the earth, conſtructed on the hypotheſis of M. BOUGUER.

Beſide the table of compariſon of the arc between Greenwich and Perpignan, which I have already endeavoured to explain, this Paper is accompanied with another, which, as well as the former, was originally intended ſolely for my own uſe. With this view it was at firſt only computed for every five minutes of the 51ſt and 52d degrees of latitude, that I might thereby be enabled more readily to compare the longitudes and latitudes of the reſpective ſtations in our progreſs towards the coaſt; and more particularly to fit it for operations in the ſouth parts of England, as likely to be firſt carried into execution. In order, however, to render it more generally uſeful, it has ſince been extended to every five degrees in the higher and lower parts of the quadrant, and to every ſingle degree in intermediate latitudes. The table not only contains the degrees of the meridian and of longitude, but alſo thoſe of a great circle perpendicular to the meridian, and likewiſe ſuch as are oblique to it, for the other ſeven points of the compaſs. With regard to the conſtruction of the table, it is only neceſſary to make

ſome

ſome remarks on that column of it, which contains the ſum of the three equations, or difference between the degree of the meridian and the correſponding degree of the great circle perpendicular to it, which is the moſt troubleſome to compute, but muſt be found before the degree of longitude can be obtained. The firſt part of M. BOUGUER's equation conſiſts of $\frac{7}{115}$ths of the difference between the degree of the meridian at the equator and that at the pole, *viz.* 545.12 fathoms, to be conſtantly added. Secondly, $\frac{3}{4}$ths of the increment of the correſponding degree of the meridian above that at the equator, to be ſubtracted; and, thirdly, $\frac{4}{115}$ths of a third proportional to the exceſs of the degree at the pole above that at the equator as radius, and the ſine of the correſponding latitude, to be added. Now it will be found, that this laſt part of the equation $\frac{4}{115}$ths, if uniformly applied, would have produced abſurd reſults at the 75th degree of latitude, that is to ſay, the degrees of a great circle would there have become greater than the degree at the pole. The equation $\frac{4}{116}$ths or $\frac{1}{4}$th would in like manner have produced abſurd reſults between the 79th and 80th degree. Even $\frac{2}{9}$ths will not go on further than the 85th; and the higheſt equation that will go through the whole quadrant, uniformly applied, muſt not exceed $\frac{80}{370}$ parts of the third proportional. M. BOUGUER himſelf had found this, and accordingly had applied the equation with a certain modification or abatement, which nevertheleſs he makes no mention of in his book. Seeing, therefore, that the degrees of a great circle perpendicular to the meridian differ moſt from thoſe of latitude about the tropics, I have, at the 20th degree, applied the equation $\frac{4}{115}$ths or $\frac{80}{3000}$ parts, and made the diviſor increaſe by unity for each degree of the quadrant above that point to the pole, where it becomes $\frac{80}{370}$ parts. Below the 20th degree

the

the diviſor, in like manner, increaſes by unity to the equator, where it becomes $\frac{8\,0}{3\,2\,0}$ parts. With reſpect to the degrees of great circles, obliquely ſituated to the meridian, they were chiefly intended for facilitating the computations of curvature and refraction, where, in any particular caſe, it might become neceſſary to obtain, to great preciſion, the relative height of a very diſtant ſtation with regard to that occupied by the inſtrument: for in ſuch caſes, in ſtrictneſs, the angle which the line makes with the meridian ſhould be attended to.

The computations * for the conſtruction of this table have been, as may eaſily be judged, ſufficiently laborious; but having once begun, I was induced to go through with them, conceiving that a table of this ſort would be of general utility; and that it might be very long indeed before the reſults of future operations, yet to be undertaken in different and very remote parts of the globe, would furniſh *data* for any thing better. It muſt be by the united efforts of enlightened nations, conſpiring as it were together in promoting the cauſe of ſcience, that great objects, ſuch as the determination of the magnitude and figure of the earth, can ultimately be obtained. Each ſhould contribute to it, and all have it more or leſs in their power, according to their particular ſituation, and that

* Much care has been beſtowed in the various computations for the conſtruction of the two tables appertaining to this Paper. In the laſt, which has been the moſt laborious, the differences ſeem to go on ſo uniformly, it is hoped, no error of any conſequence will be found. Here it is proper that I ſhould mention a typical *erratum* in one of the tables belonging to my Paper on the Barometer, publiſhed in the LXVII. volume of Tranſactions, for 1777. It is in Tab. VI. containing obſervations on heights near Carnarvon. In the column of obſerved height of Mercury on Moel Eilio, Auguſt 4, 1775, 1 h. 7 m. P. M. inſtead of 27.714 read 27.214.

portion

portion of its ſurface which has fallen to their ſhare in the general diſtribution of things.

Under the auſpices, and immediately under the eye, of a Sovereign who loves and cheriſhes the ſciences, much may be done within the limits of the Britiſh iſlands, which, reckoning from Eaſtneſs in Suffolk to the weſtern parts of Kerry in Ireland, contain near 12 degrees of longitude; and counting from the Channel on the ſouth to the Orkney iſlands only on the north about 9 degrees of latitude. With this general purpoſe in view, and at the ſame time to lay the beſt foundation for the ſurvey of the Britiſh iſlands, I would propoſe, as the operations preferably to be executed, that ſerieſes of triangles ſhould be extended along different meridians, particularly thoſe of the chief Obſervatories, and of ſome remarkable hills in the central parts of the iſland, till they fall into the ſea on the ſouth and north; and that, acroſs theſe, a great number of ſerieſes, in the parallels likewiſe of the chief Obſervatories, and of remarkable hills or eminencies, ſhould be extended from the eaſt to the weſt coaſt. The *Wrekin-hill*, on the eaſtern ſkirt of Shropſhire, ſeems to be an eligible point, being in a central ſituation, ſufficiently conſpicuous, and yet not ſo high as to render the frequent acceſs to it very inconvenient. If it ſhould be found, that longitudes may be determined by the inſtrument to the degree of accuracy which is expected, and that it may likewiſe be advantageouſly applied, independently of the zenith ſector, in tracing any parallel whoſe latitude has been already aſcertained, or the parallel of any remarkable point, whoſe meridian is known, but not its latitude; then the number of theſe *parallel ſerieſes* cannot be too much multiplied: for a great many of theſe operations executed with due care would abſolutely

abſolutely give the figure of the earth, ſince the ſhorteſt diſtance from the ſurface to its axis would thereby be obtained.

The Britiſh dominions in the Eaſt-Indies offer a ſcene particularly favourable for the meaſurement of five degrees of latitude on the coaſt of Choromandel, as has been noticed by Mr. DALRYMPLE, F. R. S. in his Paper on the Marine Survey of that Coaſt. Two degrees of longitude, at each extremity of this arc, ſhould likewiſe be meaſured.

The plains of Bengal, directly under the northern tropic, afford another ſituation where it would be of great conſequence to determine the lengths of a degree or two of latitude, and as many of longitude. Theſe two operations could not fail to be patroniſed by the Eaſt-India Company, who ſhould defray the expence; ſince, whatever tended ſo much to the improvement of ſcience in general, and ſo directly to that of navigation in particular, muſt be thought important to a Body of Merchants, whoſe power, as well as opulence, ſtand at this day unequalled in the mercantile hiſtory of the world.

But there is one operation yet to be mentioned that would contribute more than any other to the determination of the figure of the earth, which is, the accurate meaſurement of ſome degrees of longitude on the equator; becauſe thereby the length of its ſemi-diameter would be immediately known, which hitherto has only been theoretically computed from the meaſured portions of the meridian. The Portugueſe ſeem to be poſſeſſed of the moſt advantageous ſituation yet known on the globe for that purpoſe: for M. DE LA CONDAMINE has told us, that at the mouth of the river of Amazons, near the fort of *Macapa*, in three minutes north latitude, there are

extenſive open plains where an operation of this ſort would not have been ſo difficult as was at firſt imagined, when he propoſed the ſcheme to the Academy of Sciences, a year before the voyage to *Quito* was thought of. Had this been adopted as the ſcene of their operations, inſtead of that elevated valley comprehended between the lofty ranges of the *Andes*, the buſineſs would have been much ſooner accompliſhed, with infinitely leſs labour and fatigue, and ſtill more ſatisfactorily, ſince degrees of longitude as well as of latitude would probably have been meaſured. Here then the Portugueſe ſhould determine the length of two or more degrees of longitude, and as many of latitude, by way of proof or correction of the Peruvian obſervations. A well conducted operation of this kind could not fail to add to the celebrity of a nation who, by their diſcovery of the new world in the weſt, and having opened the route by the Cape of Good Hope to the eaſtern ſide of the globe, may be conſidered as the founders of modern navigation.

With regard to operations in high northern latitudes, which would doubtleſs be of great importance, the Ruſſian Empire muſt certainly afford a variety of ſituations, more or leſs difficult, for the purpoſe; and an Empreſs who commands ſo great a proportion of that region of the world, where it is ſaid exploratory diſcoveries are at preſent carrying on by her order, can ſcarcely be ſuppoſed to ſuffer a reign, otherwiſe ſo brilliant, to expire, without directing ſomething of this ſort to be executed under the polar circle, or as near to the pole as the ſeverity of the climate will permit, by way of confirmation or correction of the Lapland meaſurement, which yet ſtands ſingle and by itſelf, without any collateral proof of its exactneſs. If ſuch operations as thoſe I have ſuggeſted towards the

cloſe of this Paper were well executed in different parts of the world, little would then remain to be done towards the determination of the magnitude and figure of the earth, except multiplying, as much as poſſible, experiments with the ſame pendulums from the equator to very high ſouthern and northern latitudes, that ſome judgement might thereby be formed of the ſimilarity, or otherwiſe, of the two polar ſides of the ſpheroid.

WILL. ROY.

Feb. 22, 1787.

ERRATA.

In the Second Table ſubjoined to this Paper, page 228, under the head "Degrees of Longitude," in the column of the length of each degree in fathoms, l. 24. from the bottom (being that which anſwers to the Latitude of Greenwich) for 38161.69 read 38164.00; and in the next column of differences, l. 25. from the bottom, for 53.13 read 50.82; and the next line below, for 16.12 read 18.43.

In the Map of the Triangles, for SELSBY read SELSEY.

In the Firſt Table, p. 227. the laſt line of the laſt column but one, for 38161.7 read 38164.0.

Compariſon

Comparison of the observed length of the celestial arc of the meridian, comprehended between the parallels of

T E R R

CELESTIAL ARC

Comprehended between the parallels of Greenwich and Perpignan.

	Places of Observation.	Latitudes.	Differences of latitudes or celestial arcs. Deg.Min.&c.	Deg.	Dec. parts	Measured Arc.	Supposing the earth to be a sphere.		1		2		
		° ′ ″ ‴	° ′ ″ ‴	°		Fathoms.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fa
1	Greenwich Roy. Observ.	51 28 40 00	} 8 46 48 00	8.	78		534343.		535927.		535588.		5
	Perpignan –	42 41 52 00											
	Greenwich and M⚌	MP — — —	diff. 0 26 50 52	0.	4475		27235.		27350.		27331.		
2	Point M near Dunkirk	51 1 49 8	} 8 19 57 8	8.	3325	506499.	507108.	+ 609	508577.	+ 2078	508257.	+ 1758	5
	Perpignan –	42 41 52 00											
	Point M and Paris	— — — —	diff. 2 11 35 8	2.	1931	133417.	133467.	+ 50	133934.	+ 517	134038.	+ 621	1
3	Paris Royal Observatory	48 50 14 00	} 6 8 22 00	6.	1394	373082.	373641.	+ 559	374603.	+ 1521	374374.	+ 1292	3
	Perpignan –	42 41 52 00											
	Paris and Bourges	— — — —	diff. 1 45 9 19	1.	7525	106564.	106658.	+ 94	107007.	+ 443	106937.	+ 373	1
4	Bourges –	47 5 44 41	} 4 23 12 41	4	3869	266518.	266983.	+ 465	267596.	+ 1078	267437.	+ 918	2
	Perpignan –	42 41 52 00											
	Bourges and Rodés	— — — —	diff. 2 43 51 5	2.	6309	166009.	166200.	+ 191	166620.	+ 420	166518.	+ 509	1
5	Rodés –	44 21 13 36	} 1 39 21 36	1	656	100509.	100783.	+ 274	100976.	+ 467	100919.	+ 410	1

Mean error on each deg. + 73.09. + 249.38. + 210.98.

	Semi-diameter of the equator – –					3486975	} .00000		3504545	} 19572	3501802	} 18194	34
	Semi-axis between the poles – –					3486975			3484973		3483608		34
	Ratio of the semi-diameters – –								179.047 to	178 047	192.483 to	191.483	21
	Difference of the logarithms of the ratio –								0.0024323		0.0022622		0.0
Some other chief properties.	Degrees of the meridian at the	Equator – –				60484.5	60859.1	Error. + 374.6	60484.5	Error. 0.0	60484.5	Error. 0.0	6
		45th – –				60777.6	60859.1	+ 81.5	60993.4	+ 215.8	60957.7	+ 180.1	6
		66° 20′ – –				61194.3	60859.1	− 335.2	61342.3	+ 148.0	61281.9	+ 87.6	6
		Pole – –					60859.1		61509.3		61437.1		6
	Excess of the degree of the meridian at the pole, above that at the equator – –						00000.0		1024.8		952.6		
	Degrees of longitude at the	Equator – –					60859.1		61165.8		61117.9		6
		43° 32′ south of France –				44354.4	44121.3	− 233.1	44461.2	+ 106.8	44430.4	+ 76.0	4
		51° 28′ 40″ Greenwich –					37904 2		38225 9		38181.3		3

c of the meridian, comprehended between the parallels of Greenwich and Perpignan, with the meaſured and computed lengths of th

TERRESTRIAL ARC.

Computed arc on different *hypotheſes*.

ſing the earth to be a ſphere.		Suppoſing the Earth to be an oblate ellipſoid.											
		1		2		3		4		5		6	
ms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.
43.		535927.		535588.		535088.		534970.		533942.		533860.	
35.		27350.		27331.		27301.		27294.		27241.		27230.	
08.	+ 609	508577.	+ 2078	508257.	+ 1758	507787.	+ 1288	507676.	+ 1177	506701.	+ 202	506630.	+ 131
67.	+ 50	133934.	+ 517	134038.	+ 621	133747.	+ 330	133715.	+ 298	133454.	+ 37	133412.	− 5
41.	+ 559	374603.	+ 1521	374374.	+ 1292	374040.	+ 958	373961.	+ 879	373247.	+ 155	373218.	+ 136
58.	+ 94	107007.	+ 443	106937.	+ 373	106834.	+ 270	106810.	+ 246	106605.	+ 41	106582.	+ 18
83.	+ 465	267596.	+ 1078	267437.	+ 918	267206.	+ 688	267151.	+ 633	266642.	+ 124	266636.	+ 118
00.	+ 191	166620.	+ 420	166518.	+ 509	166370.	+ 361	166334.	+ 325	166017.	+ 8	166005.	− 4
83.	+ 274	100976.	+ 467	100919.	+ 410	100836.	+ 327	100817.	+ 308	100625.	+ 116	100631.	+ 122
	Mean error on each deg. + 73.09.		+ 249.38.		+ 210.98.		+ 154.58.		+ 141.25.		+ 24.24.		
975	.00000	3504545	19572	3501802	18194	3497814	16190	3496934	15713	3489949	15174	3487954	1123
975		3484973		3483608		3481624		3481221		3474775		3476718	
		179.047 to 0.0024323	178 047	192.483 to 0.0022622	191.483	216.06 to 0.0020148	215.06	222.55 to 0.0019558	221.55	230. to 229 0.0018924		310.3 to 0.0014018	309.3
	Error.		Error.		Error.		Error.		Error.		Error.		Error
9.1	+ 374.6	60484.5	0.0	60484.5	0.0	60484.5	0.0	60484.5		60382.6	− 101.9	60484.5	0
9.1	+ 81.5	60993.4	+ 215.8	60957.7	+ 180.1	60905.9	+ 128.3	60893.5	+ 115.9	60777.6	0.0	60777.6	0
9.1	− 335.2	61342.3	+ 148.0	61281.9	+ 87.6	61194.3	0.0	61173.4	− 20 9	61047.8	− 146.5	60977.7	− 216
9.1		61509.3		61437.1		61332.2		61308.4		61177.0		61073.0	
0.0		1024.8		952.6		847.7		823.9		794.4		588.5	
9.1		61165.8		61117.9		61048.5		61033.0		60911.1		60876.2	
1.3	− 233.1	44461.2	+ 106.8	44430.4	+ 76.0	44355.7	+ 1.3	44341.7	− 12.7	44250.1	− 104.3	44213.4	− 141
4 2		38225 9		38181.3		38130.1		38117.7		37978.7		37989.9	

Perpignan, with the meaſured and computed lengths of the correſponding terreſtrial arc between theſe parallels.

R I A L A R C.

n different *hypotheſes*.

o be an oblate ellipſoid.								Suppoſing the earth to be a ſpheroid differing from the ellipſoid.			
								More prominent in middle latitudes than the ellipſoid.		Leſs prominent in middle latitudes than the ellipſoid of the ſame ſemi-diameters.	
4		5		6		7		1		2	
Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.	Fathoms.	Error.
534970.		533942.		533860.		533751.		534997.		533737.	
27294.		27241.		27230.		27206.		27296.		27243.	
507676.	+1177	506701.	+ 202	506630.	+ 131	506545.	+ 46	507701.	+1202	506494.	− 5
133715.	+ 298	133454.	+ 37	133412.	− 5	133360.	− 57	133722.	+ 305	133438.	+21
373961.	+ 879	373247.	+ 155	373218.	+ 136	373185.	+ 103	373979.	+ 897	373056.	−26
106810.	+ 246	106605.	+ 41	106582.	+ 18	106555.	− 9	106815.	+ 251	106570.	+ 6
267151.	+ 633	266642.	+ 124	266636.	+ 118	266630.	+ 112	267164.	+ 646	266486.	−32
166334.	+ 325	166017.	+ 8	166005.	− 4	165991.	− 18	166342.	+ 333	165928.	−81
100817.	+ 308	100625.	+ 116	100631.	+ 122	100639.	+ 130	100822.	+ 313	100558.	+49
+ 141.25.		+ 24.24.		+ 15.73.		+ 5.52.		+ 144.25.		− 0.6.	
3496934	15713	3489949	15174	3487954	11236	3485542	6455	3496934	15713	3496740	19530
3481221	221.55	3474775		3476718	309.3	3479087		3481221	221.55	3477210	178.4
222.55 to		230. to 229		310.3 to		540 to 539		222.55 to		179.4 to	
0.0019558		0.0018924		0.0014018		0.0008050		0.0019558		0.0024274	
	Error.		Error.		Error.		Error.		Error.		Error.
60484.5		60382.6	− 101.9	60484.5	0.0	60609 0	+ 124.5	60484.5	0.0	60484.5	0.0
60893.5	+115.9	60777.6	0.0	60777.6	0.0	60777.6	0.0	60896.5	+ 118.9	60740.0	−37.6
61173.4	− 20 9	61047.8	− 146.5	60977.7	− 216.6	60891.6	+ 302.7	61175.7	− 18.6	61203.7	+ 9.4
61308.4		61177.0		61073.0		60947.0		61308.5		61506.6	
823.9		794.4		588.5		338.0		824.0		1022.1	
61033.0		60911.1		60876.2		60834.1		61033.0		61029.6	
44341.7	− 12.7	44250.1	− 104.3	44213.4	− 141.0	44141.9	− 212.5	44341.8	− 12.6	44373.5	+19.1
38117.7		37978.7		37989.9		37932.4		38117.2		38161.7	

Table

Table of the degrees of the Earth conſtructed on the hypotheſis of M. BOUGUER, wh
ſq

Latitudes.				Lengths of degrees of the meridian in fathoms.	Diff.	Increments above the deg. at the equator.	Diff. between deg. of the mer. and deg. of great circles perp. to the mer. or ſum of the three equations.	Degrees of great circles perpendicular to the meridian.	Diff.	Degrees of great	
										Diff.	7 points =78 ¾.
	°	′	″								
	0	0	0	60484.50	0.06	0.00	545.12	61029.62	1.95	20.75	61008.87
	0	—	—	60484.56	0.87	0.06	547.01	61031.57	5.63	20.82	61010.75
	5	—	—	60485.43	3.65	0.93	551.77	61037.20	11.52	21.00	61016.20
	10	—	—	60489.08	9.41	4.58	559.64	61048.72	16.28	21.30	61027.42
	15	—	—	60498.49	18.62	13.99	566.51	61065.00	20.65	21.56	61043.44
	20	—	—	60517.11	31.27	32.61	568.54	61085.65	25.78	21.64	61064.01
	25	—	—	60548.38	46.75	63.88	563.15	61111.53	31.14	21.43	61090.10
	30	—	—	60595.13	63.86	110.63	547.54	61142.67	36.19	20.84	61121.83
	35	—	—	60658.99		174.49	519.87	61178.86		19.78	61169.08
					14.86				7.73		
	41	—	—	60673.85	15 55	189.35	512.74	61186.59	7.95	19.51	61167.08
	42	—	—	60689.40	16.22	204.90	505.14	61194.54	8.10	19.23	61175.31
	43	—	—	60705.62	16.88	221.12	497.02	61202.64	8.26	18.92	61183.72
	44	—	—	60722.50	17.52	238.00	488.40	61210.90	8.40	18.59	61192.31
	45	—	—	60740.02	18.15	255.52	479.28	61219.30	8.51	18.24	61201.06
	46	—	—	60758.17	18.75	273.67	469.64	61227.81	8.66	17.86	61209.95
	47	—	—	60776.92	19.32	292.42	459.55	61236.47	8.77	17.49	61218.98
	48	—	—	60796.24	16.59	311.74	449.00	61245.24	7.36	17.09	61228.15
Paris	48	50	14	60812.83	3.37	328.33	439.77	61252.60	1.43	16.74	61235.86
	49	—	—	60816.10	20.37	331.60	437.93	61254.03	8.96	16.67	61237.36
	50	—	—	60836.47		351.97	426.52	61262 99		16.23	61246.76
					1.72				0.76		
	50	5	—	60838.19	1.73	353.69	425.56	61263.75	0.74	16.20	61247.55
	50	10	—	60839.92	1.72	355.42	424.57	61264.49	0.74	16.16	61248.33
	50	15	—	60841.64	1.73	357.14	423.59	61265.23	0.78	16.12	61249.11
	50	20	—	60843.37	1.74	358.87	422.64	61266.01	0.76	16.09	61249.92
	50	25	—	60845.11	1.73	360.61	421.66	61266.77	0.74	16.05	61250.72
	50	30	—	60846.84	1.74	362.34	420.67	61267.51	0.75	16.01	61251.50
	50	35	—	60848.58	1.74	364.08	419.68	61268.26	0.74	15.97	61252.29
	50	40	—	60850.32	1.75	365.82	418.68	61269.00	0.79	15.93	61253.07
	50	45	—	60852.07	1.75	367.57	417.72	61269.79	0.74	15.90	61253.89
	50	50	—	60853.82	1.75	369.32	416.71	61270.53	0.74	15.86	61254.67
	50	55	—	60855.57	1.75	371.07	415.70	61271.27	0.75	15.82	61255.45
	51	0	—	60857.32		372.82	414.70	61272.02		15.78	61256.24
					1.76				0.74		
	51	5	—	60859.08	1.76	374.58	413.68	61272.76	0.77	15.74	61257.02
	51	10	—	60860 84	1.77	376.34	412.69	61273.53	0.78	15.71	61257.82
	51	15	—	60862.61	1.76	378.11	411.70	61274.31	0.74	15.67	61258.64
	51	20	—	60864.37	1.77	379.87	410.68	61275.05	0.75	15.63	61259.42
	51	25	—	60866.14	1 30	381.64	409.66	61275.80	0.54	15.59	61260.21
Greenwich	51	28	40	60867.44	0.48	382.94	408.90	61276.34	0.21	15.56	61260.78
	51	30	—	60867.92	1.77	383.42	408.63	61276 55	0.75	15.55	61261.00
	51	35	—	60869.69	1.78	385.19	407.61	61277.30	0.74	15.51	61261.79
	51	40	—	60871.47	1.78	386.97	406.57	61278.04	0.80	15.47	61262.57
	51	45	—	60873.25	1.79	388.75	405.59	61278.84	0.74	15.44	61263.40
	51	50	—	60875.04	1.78	390.54	404.54	61279.58	0.75	15.40	61264.18
	51	55	—	60876.82	1.79	392 32	403 51	61280.33	0.76	15.36	61264.97
	52	0	0	60878.61		394.11	402.48	61281.09		15.32	61265.77
					21.69				9.09		
	53	—	—	60900.30	22.05	415.80	389.88	61290.18	9.13	14.84	61275.34

potheſis of M. BOUGUER, where the increments to the degrees of the meridian above that at th
ſquares of the ſines of the latitudes.

grees of great les perpendicu- to the meridian.	Diff.	Degrees of great circles oblique to the meridian, the differences between the meridional degrees, a perpendicular to them, being in the ratio of the ſquares of the ſines of obliquity.											
		Diff.	7 points $=78\frac{3}{4}$.	Diff.	6 points $=67°\frac{1}{2}$.	Diff.	5 points $=56°\frac{1}{4}$.	Diff.	4 points $=45°$	Diff.	3 points $=33°\frac{3}{4}$.	Diff.	2 =
29.62	1.95	20.75	61008.87	59.08	60949.79	88.43	60861.36	104.20	60757.16	104.40	60652.76	88.43	60
31.57	5.63	20.82	61010.75	59.29	60951.46	88.73	60862.73	104.66	60758.07	104.67	60653.40	88.73	60
37.20	11.52	21.00	61016.20	59.80	60956.40	89.51	60866.89	105.57	60761.32	105.58	60655.74	89.51	60
48.72	16.28	21.30	61027.42	60.66	60966.76	90 87	60875.89	107.63	60768.26	106.44	60661.82	90.78	60
65.00	20.65	21.56	61043.44	61.40	60982.04	91.90	60890 14	108.39	60781.75	108.40	60673.35	91.90	60
85.65	25.78	21.64	61064.01	61.62	61002.39	92.24	60910.15	108.77	60801.38	108.79	60692.59	92.22	60
111.53	31.14	21.43	61090.10	61.04	61029.06	91.35	60937.71	107.75	60829.96	107.76	60722.20	91.35	60
142.67	36.19	20.84	61121.83	59.35	61062.48	88.81	60973.67	104.77	60868.90	104.77	60764.13	88.81	60
178.86		19.78	61169.08	56.35	61102.73	84.33	61018.40	99.48	60918.92	99 47	60819.45	84.33	60
	7.73												
186.59		19.51	61167.08	55.58	61111.50	83.17	61028.33	98.11	60930.22	98.11	60832.11	83.17	60
194.54	7.95	19.23	61175.31	54.75	61120.56	81.94	61038.62	96.65	60941.97	96.65	60845.32	81.94	60
202.64	8.10	18.92	61183.72	53.87	61129.85	80.61	61049.24	95.11	60954.13	95.10	60859.03	80.62	60
210.90	8.26	18.59	61192.31	52.93	61139.38	79.23	61060.15	93.45	60966.70	93.45	60873.25	79.23	60
219.30	8.40	18.24	61201.06	51.95	61149.11	77.74	61071 37	91.71	60979 66	91.71	60887.95	77.74	60
227.81	8.51	17.86	61209.95	50 90	61159.05	76.18	61082.87	89.87	60993.00	89.86	60903.14	76.19	60
236.47	8.66	17.49	61218.98	49 81	61169.17	74.55	61094.62	87.93	61006.69	87.93	60918.76	74.54	60
245.24	8.77	17.09	61228.15	48.66	61179 49	72.84	61106.65	85.91	61020.74	85.91	60934.83	72 84	60
252.60	7.36	16.74	61235.86	47.66	61188.20	71.34	61116.86	84.15	61032.71	84.14	60948.57	71.34	60
254.03	1.43	16.67	61237.36	47.46	61189.90	71.04	61118.86	83.80	61035.06	83.79	60951.27	71.04	60
262 99	8.96	16.23	61246.76	46.23	61200.53	69 19	61131.34	81.61	61049.73	81.61	60968.12	69.19	60
	0.76												
263.75		16.20	61247.55	46.12	61201.43	69.03	61132 40	81.43	61050.97	81.43	60969.54	69.03	60
264.49	0.74	16.16	61248.33	46.02	61202.31	68.87	61133.44	81.23	61052 21	81.24	60970.97	68.87	60
265.23	0.74	16.12	61249.11	45.91	61203.20	68.71	61134 49	81.06	61053.43	81.05	60972.38	68.71	60
266.01	0.78	16.09	61249.92	45.80	61204.12	68.56	61135 56	80.87	61054.69	80.87	60973.82	68.56	60
266.77	0.76	16.05	61250.72	45.70	61205.02	68.40	61136.62	80.68	61055 94	80.68	60975.26	68.40	60
267.51	0.74	16.01	61251.50	45.60	61205.90	68.23	61137.67	80.50	61057.17	80.49	60976.68	68.23	60
268.26	0.75	15.97	61252.29	45.49	61206.80	68.08	61138.72	80.30	61058.42	80.30	60978.12	68.08	60
269.00	0.74	15.93	61253.07	45.38	61207.69	67.92	61139.77	80.11	61059.66	80.11	60979.55	67.92	60
269.79	0.79	15.90	61253.89	45.27	61208.62	67.76	61140.86	79.93	61060.93	79.93	60981.00	67.76	60
270.53	0.74	15.86	61254.67	45.17	61209.50	67.59	61141.91	79.74	61062.17	79.73	60982.44	67.59	60
271.27	0.74	15.82	61255.45	45.06	61210.39	67.43	61142.96	79.54	61063.42	79.54	60983.88	67.43	60
272.02	0.75	15.78	61256.24	44.95	61211.29	67.27	61144.02	79.35	61064.67	79.35	60985.32	67.27	60
	0.74												
272.76		15.74	61257.02	44.84	61212.18	67.11	61145.07	79.15	61065.92	79.15	60986.77	67.11	60
273.53	0.77	15.71	61257.82	44.73	61213.09	66.94	61146.15	78.96	61067.19	78.97	60988.22	66.94	60
274.31	0.78	15.67	61258.64	44 62	61214 02	66.79	61147.23	78.77	61068.46	78.78	60989.68	66.78	60
275.05	0.74	15.63	61259.42	44.51	61214.91	66.62	61148.29	78.58	61069.71	78.58	60991.13	66.62	60
275.80	0.75	15.59	61260.21	44.40	61215.81	66.45	61149.36	78.39	61070.97	78.39	60992.58	66.45	60
276.34	0.54	15.56	61260.78	44.32	61216.46	66.33	61150.13	78 24	61071.89	78 24	60993.65	66.33	60
276 55	0.21	15.55	61261.00	44.29	61216.71	66.29	61150 42	78.18	61072.24	78.19	60994.05	66.29	60
277.30	0.75	15.51	61261.79	44.18	61217 61	66.12	61151.49	78.00	61073.49	77.99	60995.50	66.12	60
278.04	0.74	15.47	61262.57	44.07	61218.50	65 95	61152.55	77.79	61074.76	77.80	60996.96	65.95	60
278.84	0.80	15.44	61263.40	43.95	61219.45	65.80	61153 65	77.60	61076.05	77.61	60998.44	65.80	60
279.58	0.74	15.40	61264.18	43.84	61220.34	65.62	61154.72	77.41	61077.31	77.41	60999.90	65.62	60
280.33	0.75	15.36	61264.97	43.73	61221.24	65.46	61155.78	77.21	61078.57	77.20	61001.37	65.46	60
281.09	0.76	15.32	61265.77	43.62	61222.15	65.29	61156.86	77.01	61079.85	77 01	61002.84	65.29	60
	9.09												
290.18		14.84	61275.34	42.26	61233.08	63.24	61169.84	74.60	61095.24	74.60	61020.64	63.24	60
291.31	9.13	14.35	61284.96	40.86	61244.10	61.14	61182.96	72.13	61110.83	72.13	61028.70	61.15	60

the meridian above that at the equator follow the ratio of the 4th power, or ſquared

s between the meridional degrees, and thoſe of great circles
ſquares of the ſines of obliquity.

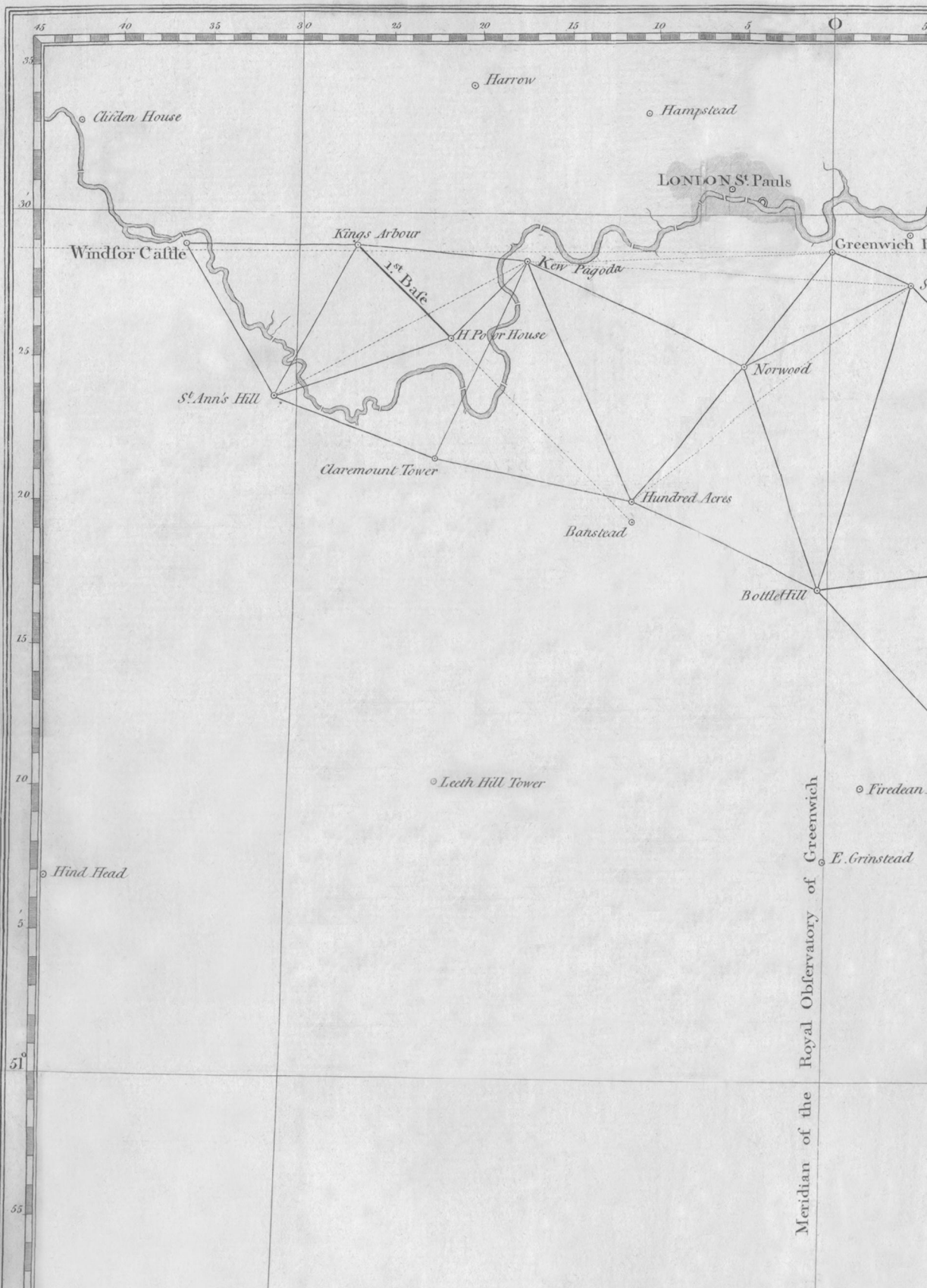
points =45°	Diff.	3 points =33°¾.	Diff.	2 points =22°½.	Diff.	1 point =11°¼.	Degrees of longitude.	Diff.	Latitudes.	°	′	″
57.16	104.40	60652.76	88.43	60564.33	59.08	60505.25	61029.62			0	0	0
								230.28				
58.07	104.67	60653.40	88.73	60564.67	59.22	60505.45	60799.34			5	–	–
								689.48				
61.32	105.58	60655.74	89.51	60566.23	59.80	60506.43	60109.86			10	–	–
								1141.33				
68.26	106.44	60661.82	90.78	60571.04	60.66	60510.38	58968.53			15	–	–
								1586.20				
81.75	108.40	60673.35	91.90	60581.45	61.40	60520.05	57382 33			20	–	–
								2019.94				
01.38	108.79	60692.59	92.22	60600.37	61.62	60538.75	55362.39			25	–	–
								2438.26				
29.96	107.76	60722.20	91.35	60630.85	61.04	60569.81	52924.13			30	–	–
								2839.00				
68.90	104.77	60764.13	88.81	60675.32	59.35	60615.97	50085.13			35	–	–
								3219.39				
18.92	99 47	60819.45	84.33	60735.12	56.34	60678.78	46865.74			40	–	–
								687.62				
30.22	98.11	60832.11	83.17	60748.94	56.58	60693.36	46178.12			41	–	–
								701.72				
41.97	96.65	60845.32	81.94	60763.38	54.75	60708.63	45476.40			42	–	–
								715.63				
54.13	95.10	60859.03	80.62	60778.41	53.87	60724.54	44760.77			43	–	–
								729.34				
66.70	93.45	60873.25	79.23	60794.02	52.93	60741.09	44031.43			44	–	–
								742.85				
79 66	91.71	60887.95	77.74	60810.21	51.95	60758.26	43288.58			45	–	–
								756.17				
93.00	89.86	60903.14	76.19	60826.95	50 91	60776.04	42532.41			46	–	–
								769.24				
06.69	87.93	60918.76	74.54	60844.22	49.81	60794.41	41763.17			47	–	–
								782.11				
20.74	85.91	60934.83	72 84	60861.99	48.66	60813.33	40981.06			48	–	–
								664.55				
32.71	84.14	60948.57	71.34	60877.23	47.66	60829.57	40316.51		Paris.	48	50	14
								130.25				
35.06	83.79	60951.27	71.04	60880.23	47.46	60832.77	40186.26			49	–	–
								807.17				
49.73	81.61	60968.12	69.19	60898.93	46.23	60852.70	39379.09			50	–	–
								67.80				
50.97	81.43	60969.54	69.03	60900.51	46.12	60854.39	39311.29			50	5	–
								67.90				
52 21	81.24	60970.97	68.87	60902.10	46.02	60856.08	39243.39			50	10	–
								68.02				
53.43	81.05	60972.38	68.71	60903.67	45.91	60857.76	39175.37			50	15	–
								68.05				
54.69	80.87	60973.82	68.56	60905.26	45.80	60859.46	39107.32			50	20	–
								68.14				
55 94	80.68	60975.26	68.40	60906.86	45.70	60861.16	39039.18			50	25	–
								68.24				
57.17	80.49	60976.68	68.23	90908.45	45.60	60862.85	38970.94			50	30	–
								68.32				
58.42	80.30	60978.12	68.08	60910.04	45 49	60864.55	38902.62			50	35	–
								68.40				
59.66	80.11	60979.55	67.92	60911.63	45.37	60866.26	38834.22			50	40	–
								68.50				
60.93	79.93	60981.00	67.76	60913.24	45.27	60867.97	38765.72			50	45	–
								68.57				
62.17	79.73	60982.44	67.59	60914.85	45.17	60869.68	38697.15			50	50	–
								68.67				
63.42	79.54	60983.88	67.43	60916.45	45.06	60871.39	38628.48			50	55	–
								68.76				
64.67	79.35	60985.32	67.27	60918.05	44.95	60873.10	38559.72			51	0	0
								68.82				
65.92	79.15	60986.77	67.11	60919.66	44.84	60874.82	38490.90			51	5	–
								68.90				
67.19	78.97	60988.22	66.94	60921.28	44.73	60876.55	38422.00			51	10	–
								68.97				
68.46	78.78	60989.68	66.78	60922.90	44.62	60878.28	38353.03			51	15	–
								69.06				
69.71	78.58	60991.13	66.62	60924.51	44.51	60880.00	38283.97			51	20	–
								69.15				
70.97	78.39	60992.58	66.45	60926.13	44.40	60881.73	38214.82			51	25	–
								53.13				
71.89	78 24	60993.65	66.33	60927.32	44.32	60883.00	38161.69		Greenwich	51	28	40
								16.12				
72.24	78.19	60994.05	66.29	60927.76	44.29	60883.47	38145.57			51	30	–
								69.33				
73.49	77.99	60995.50	66.12	60929.38	44.18	60885.20	38076.24			51	35	–
								69.41				
74.76	77.80	60996.96	65.95	60931.01	44.07	60886.94	38006.83			51	40	–
								69.49				
76.05	77.61	60998.44	65.80	60932.64	43 95	60888.69	37937.34			51	45	–
								69.57				
77.31	77.41	60999.90	65.62	60934.28	43.84	60890.44	37867.77			51	50	–
								69.65				
78.57	77.20	61001.37	65.46	60935.91	43.73	60892.18	37798.12			51	55	–
								69.72				
79.85	77 01	61002.84	65.29	60937.55	43.62	60893.93	37728.40			52	0	0
								843.05				
95.24	74.60	61020.64	63.24	60957.40	42.26	60915.14	36885.35			53	–	–
								854.52				
10.83	72.13	61028.79	61.15	60977.55	40.85	60936.70	36030.83			54		

	30	–	–	60548.38	46.75	63.88	563.15	61111.53	31.14	20.84 61121.83
	35	–	–	60595.13	63.86	110.63	547.54	61142.67	36.19	19.78 61169.08
	40	–	–	60658.99		174.49	519.87	61178.86		
					14.86				7.73	
						189.35	512.74	61186.59		19.51 61167.08
	41	–	–	60673.85	15 55	204.90	505.14	61194.54	7.95	19.23 61175.31
	42	–	–	60689.40	16.22	221.12	497.02	61202.64	8.10	18.92 61183.72
	43	–	–	60705.62	16.88	238.00	488.40	61210.90	8.26	18.59 61192.31
	44	–	–	60722.50	17.52	255.52	479.28	61219.30	8.40	18.24 61201.06
	45	–	–	60740.02	18.15	273.67	469.64	61227.81	8.51	17.86 61209.95
	46	–	–	60758.17	18.75	292.42	459.55	61236.47	8.66	17.49 61218.98
	47	–	–	60776.92	19.32	311.74	449.00	61245.24	8.77	17.09 61228.15
	48	–	–	60796.24	16.59	328.33	439.77	61252.60	7.36	16.74 61235.86
Paris	48	50	14	60812.83	3.37	331.60	437.93	61254.03	1.43	16.67 61237.36
	49	–	–	60816.10	20.37	351.97	426.52	61262 99	8.96	16.23 61246.76
	50	–	–	60836.47						
					1.72				0.76	
						353.69	425.56	61263.75		16.20 61247.55
	50	5	–	60838.19	1.73	355.42	424.57	61264.49	0.74	16.16 61248.33
	50	10	–	60839.92	1.72	357.14	423.59	61265.23	0.74	16.12 61249.11
	50	15	–	60841.64	1.73	358.87	422.64	61266.01	0.78	16.09 61249.92
	50	20	–	60843.37	1.74	360.61	421.66	61266.77	0.76	16.05 61250.72
	50	25	–	60845.11	1.73	362.34	420.67	61267.51	0.74	16.01 61251.50
	50	30	–	60846.84	1.74	364.08	419.68	61268.26	0.75	15.97 61252.29
	50	35	–	60848.58	1.74	365.82	418.68	61269.00	0.74	15.93 61253.07
	50	40	–	60850.32	1.75	367.57	417.72	61269.79	0.79	15.90 61253.89
	50	45	–	60852.07	1.75	369.32	416.71	61270.53	0.74	15.86 61254.67
	50	50	–	60853.82	1.75	371.07	415.70	61271.27	0.74	15.82 61255.45
	50	55	–	60855.57	1.75	372.82	414.70	61272.02	0.75	15.78 61256.24
	51	0	–	60857.32						
					1.76				0.74	
						374.58	413.68	61272.76		15.74 61257.02
	51	5	–	60859.08	1.76	376.34	412.69	61273.53	0.77	15.71 61257.82
	51	10	–	60860 84	1.77	378.11	411.70	61274.31	0.78	15.67 61258.64
	51	15	–	60862.61	1.76	379.87	410.68	61275.05	0.74	15.63 61259.42
	51	20	–	60864.37	1.77	381.64	409.66	61275.80	0.75	15.59 61260.21
	51	25	–	60866.14	1 30	382.94	408.90	61276.34	0.54	15.56 61260.78
Greenwich	51	28	40	60867.44	0.48	383.42	408.63	61276 55	0.21	15.55 61261.00
	51	30	–	60867.92	1.77	385.19	407.61	61277.30	0.75	15.51 61261.79
	51	35	–	60869.69	1.78	386.97	406.57	61278.04	0.74	15.47 61262.57
	51	40	–	60871.47	1.78	388.75	405.59	61278.84	0.80	15.44 61263.40
	51	45	–	60873.25	1.79	390.54	404.54	61279.58	0.74	15.40 61264.18
	51	50	–	60875.04	1.78	392.32	403 51	61280.33	0.75	15.36 61264.97
	51	55	–	60876.82	1.79	394.11	402.48	61281.09	0.76	15.32 61265.77
	52	0	0	60878.61						
					21.69				9.09	
						415.80	389.88	61290.18		14.84 61275.34
	53	–	–	60900.30	22.05	437.85	376.96	61299.31	9.13	14.35 61284.96
	54	–	–	60922.35	22.35	460.20	363.75	61308.45	9.14	13.84 61294.61
	55	–	–	60944.70	22.63	482.83	350.26	61317.59	9.14	13.33 61304.26
	56	–	–	60967.33	22.83	505.66	336.53	61326.69	9.10	12.81 61313.88
	57	–	–	60990.16	23.00	528.66	322.60	61335.76	9.07	12.28 61323.48
	58	–	–	61013.16	16.46				6.45	
Equal to deg. of long. on the equator.	58	42	47.4	61029.62	6.65	545.12	312.59	61342.21	2.57	11 90 61330.31
	59	–	0	61036.27	23.16	551.77	308.51	61344.78	8.94	11.74 61333.04
	60	–	0	61059.43		574.93	294.29	61353.72		11.20 61342.52
					114.67				42.98	
						689.60	222.60	61396.70		8.47 61388.23
	65	–	–	61174.10	29.65				10 80	
Deg. meas. in Lapland.	66	20	–	61203.75	77.71	719.25	203.75	61407.50	27.89	7.75 61399.75
	70	–	–	61281.46	92.79	796.96	153.70	61435.16	31.80	5.85 61429.31
	75	–	–	61374.25	71.64	889.75	92.71	61466.96	24.31	3.53 61463.43
	80	–	–	61445.89	45.24	961.39	45.38	61491.27	12 33	1.73 61489 54
	85	–	–	61491.13	15.47	1006.63	12.47	61503.60	3.00	0.47 61503.13
	90	–	–	61506.60		1022.10	0.00	61506.60		0.00 61506.60

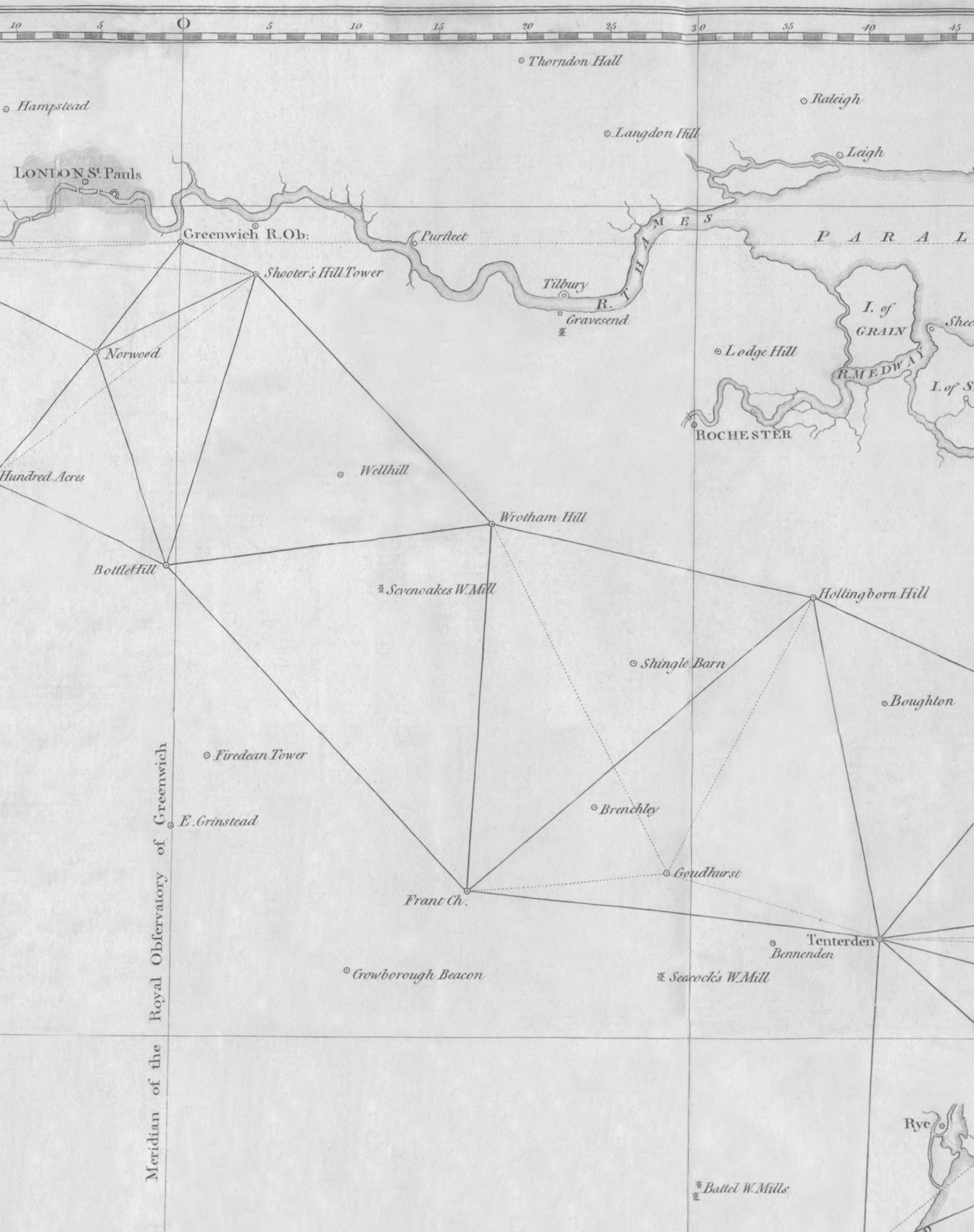
31.14	20.84	61121.83	59.35	61062.48	88.81	60973.67	104.77	60868.90	104.77	60764.13	88.81	60
36.19	19.78	61169.08	56.35	61102.73	84.33	61018.40	99.48	60918.92	99 47	60819.45	84.33	60
7.73												
	19.51	61167.08	55.58	61111.50	83.17	61028.33	98.11	60930.22	98.11	60832.11	83.17	60
7.95	19.23	61175.31	54.75	61120.56	81.94	61038.62	96.65	60941.97	96.65	60845.32	81.94	60
8.10	18.92	61183.72	53.87	61129.85	80.61	61049.24	95.11	60954.13	95.10	60859.03	80.62	60
8.26	18.59	61192.31	52.93	61139.38	79.23	61060.15	93.45	60966.70	93.45	60873.25	79.23	60
8.40	18.24	61201.06	51.95	61149.11	77.74	61071 37	91.71	60979 66	91.71	60887.95	77.74	60
8.51	17.86	61209.95	50 90	61159.05	76.18	61082.87	89.87	60993.00	89.86	60903.14	76.19	60
8.66	17.49	61218.98	49 81	61169.17	74.55	61094.62	87.93	61006.69	87.93	60918.76	74.54	60
8.77	17.09	61228.15	48.66	61179 49	72.84	61106.65	85.91	61020.74	85.91	60934.83	72 84	60
7.36	16.74	61235.86	47.66	61188.20	71.34	61116.86	84.15	61032.71	84.14	60948.57	71.34	60
1.43	16.67	61237.36	47.46	61189.90	71.04	61118.86	83.80	61035.06	83.79	60951.27	71.04	60
8.96	16.23	61246.76	46.23	61200.53	69 19	61131.34	81.61	61049.73	81.61	60968.12	69.19	60
0.76												
	16.20	61247.55	46.12	61201.43	69.03	61132 40	81.43	61050.97	81.43	60969.54	69.03	60
0.74	16.16	61248.33	46.02	61202.31	68.87	61133.44	81.23	61052 21	81.24	60970.97	68.87	60
0.74	16.12	61249.11	45.91	61203.20	68.71	61134 49	81.06	61053.43	81.05	60972.38	68.71	60
0.78	16.09	61249.92	45.80	61204.12	68.56	61135 56	80.87	61054.69	80.87	60973.82	68.56	60
0.76	16.05	61250.72	45.70	61205.02	68.40	61136.62	80.68	61055 94	80.68	60975.26	68.40	60
0.74	16.01	61251.50	45.60	61205.90	68.23	61137.67	80.50	61057.17	80.49	60976.68	68.23	60
0.75	15.97	61252.29	45.49	61206.80	68.08	61138.72	80.30	61058.42	80.30	60978.12	68.08	60
0.74	15.93	61253.07	45.38	61207.69	67.92	61139.77	80.11	61059.66	80.11	60979.55	67.92	60
0.79	15.90	61253.89	45.27	61208.62	67.76	61140.86	79.93	61060.93	79.93	60981.00	67.76	60
0.74	15.86	61254.67	45.17	61209.50	67.59	61141.91	79.74	61062.17	79.73	60982.44	67.59	60
0.74	15.82	61255.45	45.06	61210.39	67.43	61142.96	79.54	61063.42	79.54	60983.88	67.43	60
0.75	15.78	61256.24	44.95	61211.29	67.27	61144.02	79.35	61064.67	79.35	60985.32	67.27	60
0.74												
	15.74	61257.02	44.84	61212.18	67.11	61145.07	79.15	61065.92	79.15	60986.77	67.11	60
0.77	15.71	61257.82	44.73	61213.09	66.94	61146.15	78.96	61067.19	78.97	60988.22	66.94	60
0.78	15.67	61258.64	44 62	61214 02	66.79	61147.23	78.77	61068.46	78.78	60989.68	66.78	60
0.74	15.63	61259.42	44.51	61214.91	66.62	61148.29	78.58	61069.71	78.58	60991.13	66.62	60
0.75	15.59	61260.21	44.40	61215.81	66.45	61149.36	78.39	61070.97	78.39	60992.58	66.45	60
0.54	15.56	61260.78	44.32	61216.46	66.33	61150.13	78 24	61071.89	78 24	60993.65	66.33	60
0.21	15.55	61261.00	44.29	61216.71	66.29	61150 42	78.18	61072.24	78.19	60994.05	66.29	60
0.75	15.51	61261.79	44.18	61217 61	66.12	61151.49	78.00	61073.49	77.99	60995.50	66.12	60
0.74	15.47	61262.57	44.07	61218.50	65 95	61152.55	77.79	61074.76	77.80	60996.96	65.95	60
0.80	15.44	61263.40	43.95	61219.45	65.80	61153 65	77.60	61076.05	77.61	60998.44	65.80	60
0.74	15.40	61264.18	43.84	61220.34	65.62	61154.72	77.41	61077.31	77.41	60999.90	65.62	60
0.75	15.36	61264.97	43.73	61221.24	65.46	61155.78	77.21	61078.57	77.20	61001.37	65.46	60
0.76	15.32	61265.77	43.62	61222.15	65.29	61156.86	77.01	61079.85	77 01	61002.84	65.29	60
9.09												
	14.84	61275.34	42.26	61233.08	63.24	61169.84	74.60	61095.24	74.60	61020.64	63.24	60
9.13	14.35	61284.96	40.86	61244.10	61.14	61182.96	72.13	61110.83	72.13	61038.70	61.15	60
9.14	13.84	61294.61	39.43	61255.18	59.00	61196.18	69.60	61126.58	69.61	61056.97	59.00	60
9.14	13.33	61304.26	37.96	61266.30	56.82	61209.48	67.02	61142.46	67.02	61075.44	56 82	61
9.10	12.81	61313.88	36.47	61277.41	54.59	61222.82	64.39	61158.43	64.40	61094.03	54 59	61
9.07	12.28	61323.48	34.96	61288.52	52.33	61236.19	61.73	61174.46	61.73	61112.73	52.33	61
6.45												
	11 90	61330.31	33.88	61296.43	50.70	61245 73	59.82	61185.91	59.81	61126.10	50.70	61
2.57												
	11.74	61333.04	33.44	61299.60	50.05	61249.55	59.03	61190.52	59 03	61131.49	50.04	61
8.94	11.20	61342.52	31.90	61310.62	47.74	61262.88	56.31	61206.57	56.30	61150.27	47.74	61
42.98												
	8.47	61388.23	24.13	61364.10	36.11	61327.99	42.59	61285.40	42.59	61242.81	36.11	61
10 80												
	7.75	61399.75	22.09	61377.66	33.05	61344.61	38.98	61305.63	38.99	61266.64	33.05	61
27.89												
	5.85	61429.31	16.66	61412.65	24.93	61387.72	29.41	61358.31	29.41	61328.90	24.93	61
31.80	3.53	61463.43	10.05	61453.38	15.04	61438.34	17.74	61420.60	17.73	61402.87	15.04	61
24.31	1.73	61489 54	4.92	61484.62	7 36	61477.26	8.68	61468.58	8 68	61459.90	7.36	61
12 33	0.47	61503.13	1.36	61501.77	2.02	61499 75	2 38	61497.37	2.39	61494.98	2.02	61
3.00	0.00	61506.60	0.00	61506.60	0.00	61506.60	0.00	61506.60	0 00	61506.60	0.00	61

68.90	104.77	60764.13	88.81	60675.32	59.35	60615.97	50085.13	2839.00		30	– –
18.92	99 47	60819.45	84.33	60735.12	56.34	60678.78	46865.74	3219.39		35	– –
										40	– –
30.22	98.11	60832.11	83.17	60748.94	56.58	60693.36	46178.12	687.62			
41.97	96.65	60845.32	81.94	60763.38	54.75	60708.63	45476.40	701.72		41	– –
54.13	95.10	60859.03	80.62	60778.41	53.87	60724.54	44760.77	715.63		42	– –
66.70	93.45	60873.25	79.23	60794.02	52.93	60741.09	44031.43	729.34		43	– –
79 66	91.71	60887.95	77.74	60810.21	51.95	60758.26	43288.58	742.85		44	– –
93.00	89.86	60903.14	76.19	60826.95	50 91	60776.04	42532.41	756.17		45	– –
06.69	87.93	60918.76	74.54	60844.22	49.81	60794.41	41763.17	769.24		46	– –
20.74	85.91	60934.83	72 84	60861.99	48.66	60813.33	40981.06	782.11		47	– –
32.71	84.14	60948.57	71.34	60877.23	47.66	60829.57	40316.51	664.55		48	– –
35.06	83.79	60951.27	71.04	60880.23	47.46	60832.77	40186.26	130.25	Paris.	48	50 14
49.73	81.61	60968.12	69.19	60898.93	46.23	60852.70	39379.09	807.17		49	– –
										50	– –
50.97	81.43	60969.54	69.03	60900.51	46.12	60854.39	39311.29	67.80			
52 21	81.24	60970.97	68.87	60902.10	46.02	60856.08	39243.39	67.90		50	5 –
53.43	81.05	60972.38	68.71	60903.67	45.91	60857.76	39175.37	68.02		50	10 –
54.69	80.87	60973.82	68.56	60905.26	45.80	60859.46	39107.32	68.05		50	15 –
55 94	80.68	60975.26	68.40	60906.86	45.70	60861.16	39039.18	68.14		50	20 –
57.17	80.49	60976.68	68.23	90908.45	45.60	60862.85	38970.94	68.24		50	25 –
58.42	80.30	60978.12	68.08	60910.04	45 49	60864.55	38902.62	68.32		50	30 –
59.66	80.11	60979.55	67.92	60911.63	45.37	60866.26	38834.22	68.40		50	35 –
60.93	79.93	60981.00	67.76	60913.24	45.27	60867.97	38765.72	68.50		50	40 –
62.17	79.73	60982.44	67.59	60914.85	45.17	60869.68	38697.15	68.57		50	45 –
63.42	79.54	60983.88	67.43	60916.45	45.06	60871.39	38628.48	68.67		50	50 –
64.67	79.35	60985.32	67.27	60918.05	44.95	60873.10	38559.72	68.76		50	55 –
								68.82		51	0 0
65.92	79.15	60986.77	67.11	60919.66	44.84	60874.82	38490.90	68.90		51	5 –
67.19	78.97	60988.22	66.94	60921.28	44.73	60876.55	38422.00	68.97		51	10 –
68.46	78.78	60989.68	66.78	60922.90	44.62	60878.28	38353.03	69.06		51	15 –
69.71	78.58	60991.13	66.62	60924.51	44.51	60880.00	38283.97	69.15		51	20 –
70.97	78.39	60992.58	66.45	60926.13	44.40	60881.73	38214.82	53.13		51	25 –
71.89	78 24	60993.65	66.33	60927.32	44.32	60883.00	38161.69	16.12	Greenwich	51	28 40
72.24	78.19	60994.05	66.29	60927.76	44.29	60883.47	38145.57	69.33		51	30 –
73.49	77.99	60995.50	66.12	60929.38	44.18	60885.20	38076.24	69.41		51	35 –
74.76	77.80	60996.96	65.95	60931.01	44.07	60886.94	38006.83	69.49		51	40 –
76.05	77.61	60998.44	65.80	60932.64	43 95	60888.69	37937.34	69.57		51	45 –
77.31	77.41	60999.90	65.62	60934.28	43.84	60890.44	37867.77	69.65		51	50 –
78.57	77.20	61001.37	65.46	60935.91	43.73	60892.18	37798.12	69.72		51	55 –
79.85	77 01	61002.84	65.29	60937.55	43.62	60893.93	37728.40			52	0 0
								843.05			
95.24	74.60	61020.64	63.24	60957.40	42.26	60915.14	36885.35	854.52		53	– –
10.83	72.13	61038.70	61.15	60977.55	40.85	60936.70	36030.83	865.75		54	– –
26.58	69.61	61056.97	59.00	60997.97	39.43	60958.54	35165.08	876.72		55	– –
42.46	67.02	61075.44	56 82	61018.62	37.96	60980.66	34288.36	887.45		56	– –
58.43	64.40	61094.03	54 59	61039.44	36.47	61002.97	33400.91	897.37		57	– –
74.46	61.73	61112.73	52.33	61060 40	34.96	61025.44	32503.54	647.12		58	– –
85.91	59.81	61126.10	50.70	61075.40	33 88	61041.52	31856.42	261.52	Equal to deg. of long. on the equator.	58	42 47,4
90.52	59 03	61131.49	50.04	61081.45	33.44	61048.01	31594.90	918.04		59	– –
06.57	56.30	61150.27	47.74	61102.53	31.90	61070.63	30676.86			60	– –
								4729.49			
85.40	42.59	61242.81	36.11	61206.70	24.13	61182.57	25947.37	1297.48		65	– –
05.63	38.99	61266.64	33.05	61233.59	22.09	61211.50	24649.89	3637.83	Deg. meaf. in Lapland.	66	20 –
58.31	29.41	61328.90	24.93	61303.97	16.62	61287.35	21012.06	5103.24		70	– –
20.60	17.73	61402.87	15.04	61387.83	9.55	61377.78	15908.82	5330.97		75	– –
68.58	8 68	61459.90	7.36	61452.54	4 92	61447.62	10677.85	5317.45		80	– –
97.37	2.39	61494.98	2.02	61492.96	1.36	61491.60	5360.40	5360 40		85	– –
06.60	0 00	61506.60	0.00	61506.60	0.00	61506.60	00.00			90	– –

MAP *shewing nearly the* DISPOSITIO



he DISPOSITION of the TRIANGLES, whereby it is

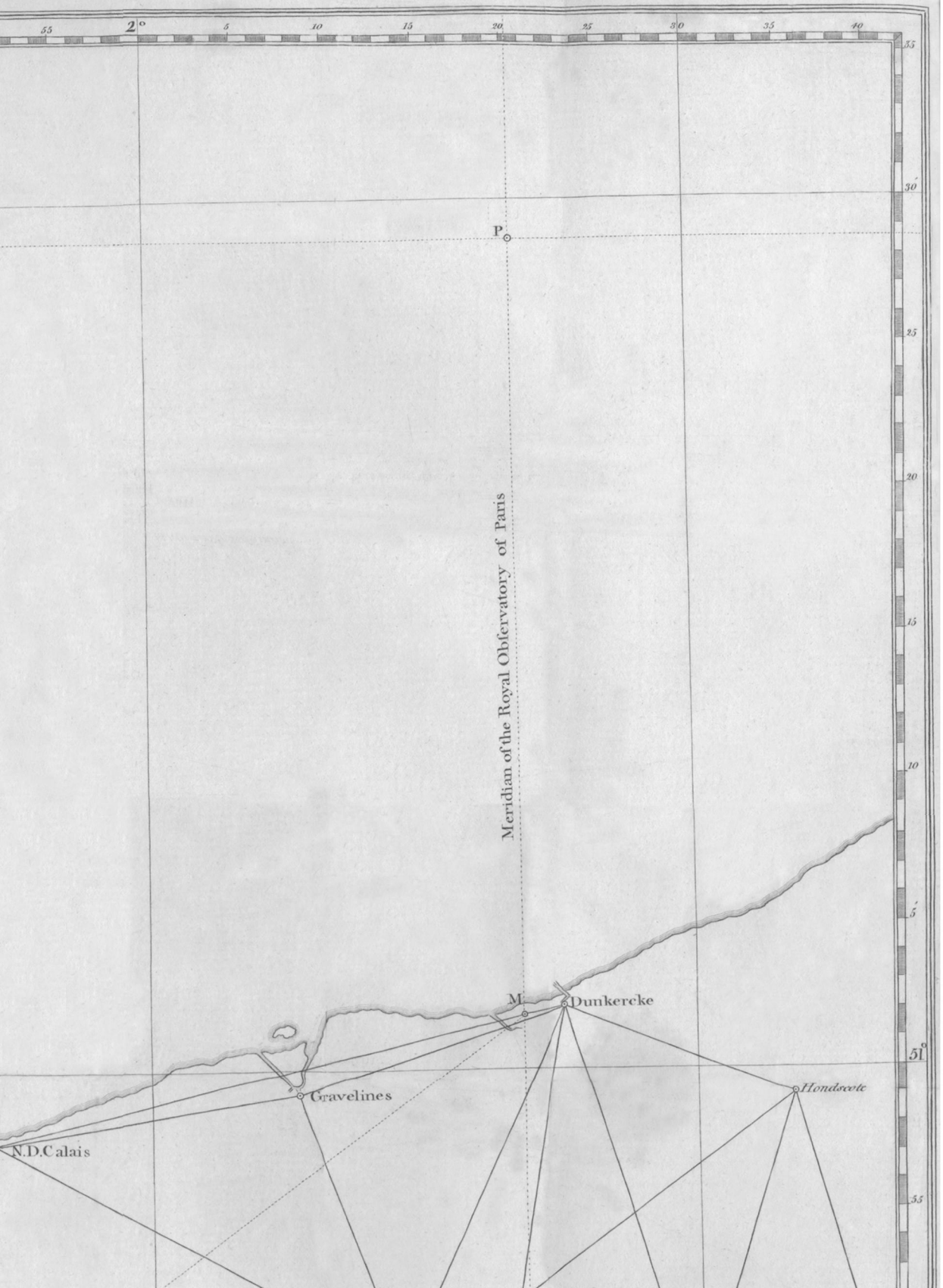


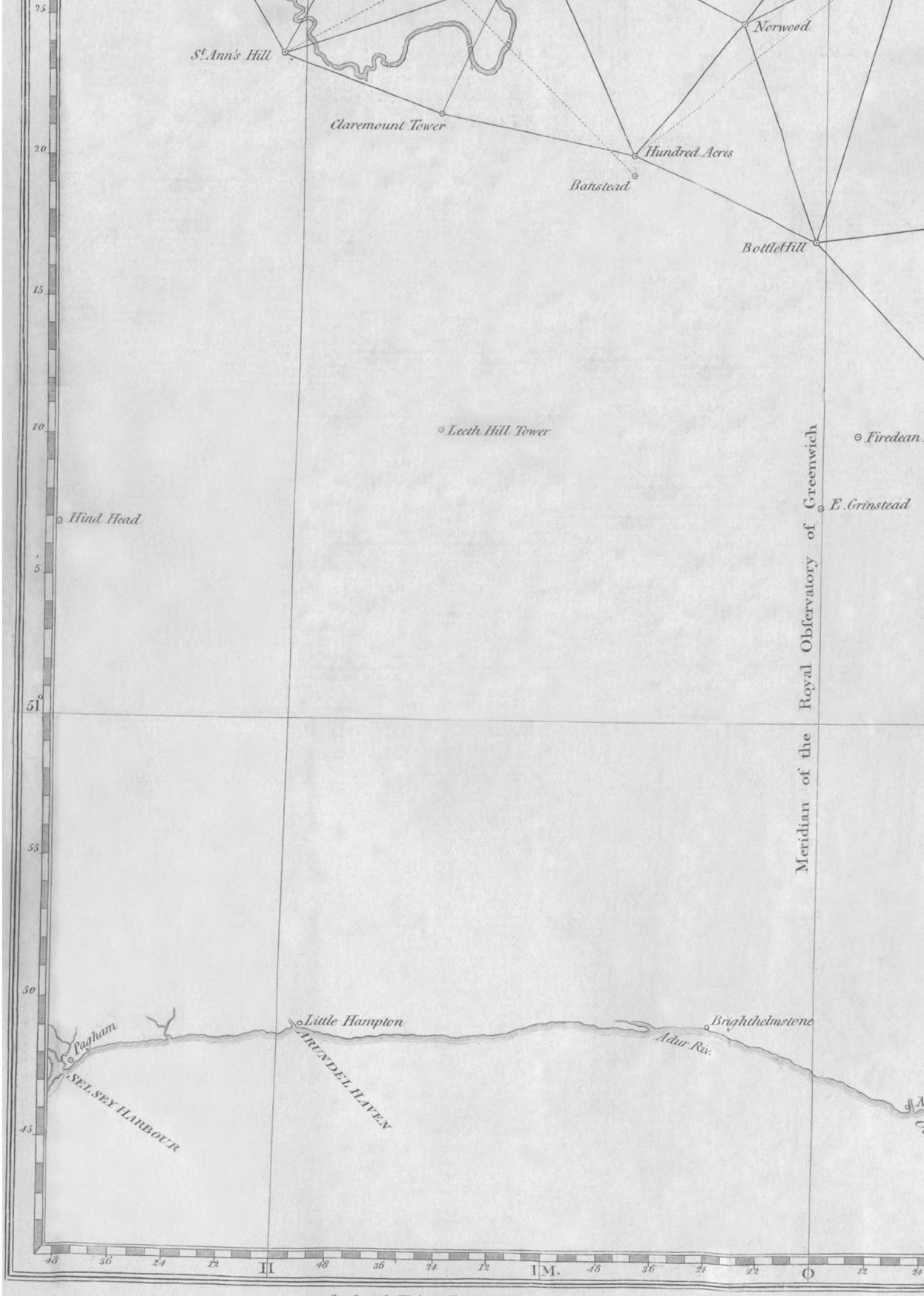
S, whereby it is proposed to determine the Relative Situa

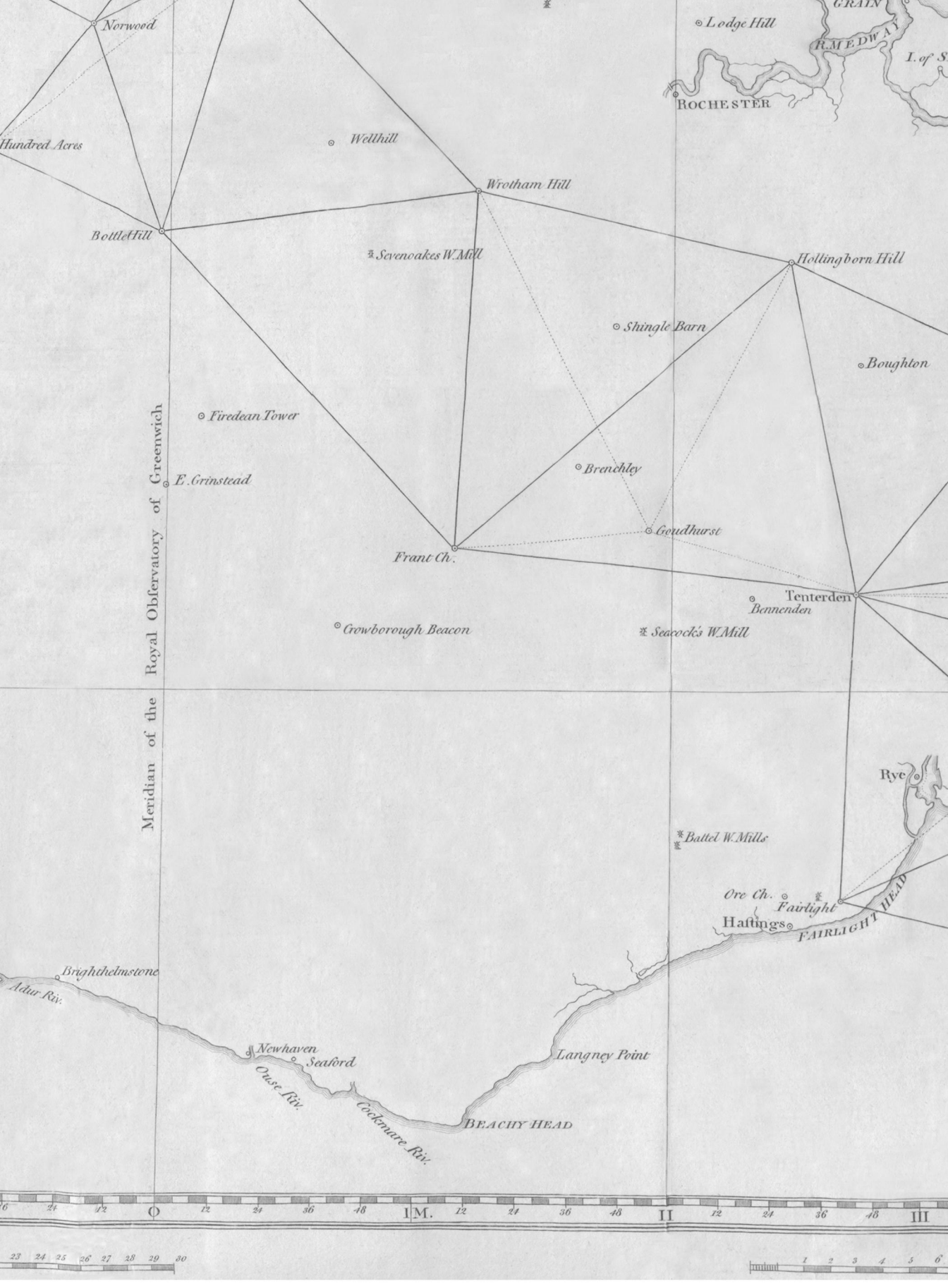
he Relative Situations of the Royal Observatories of G

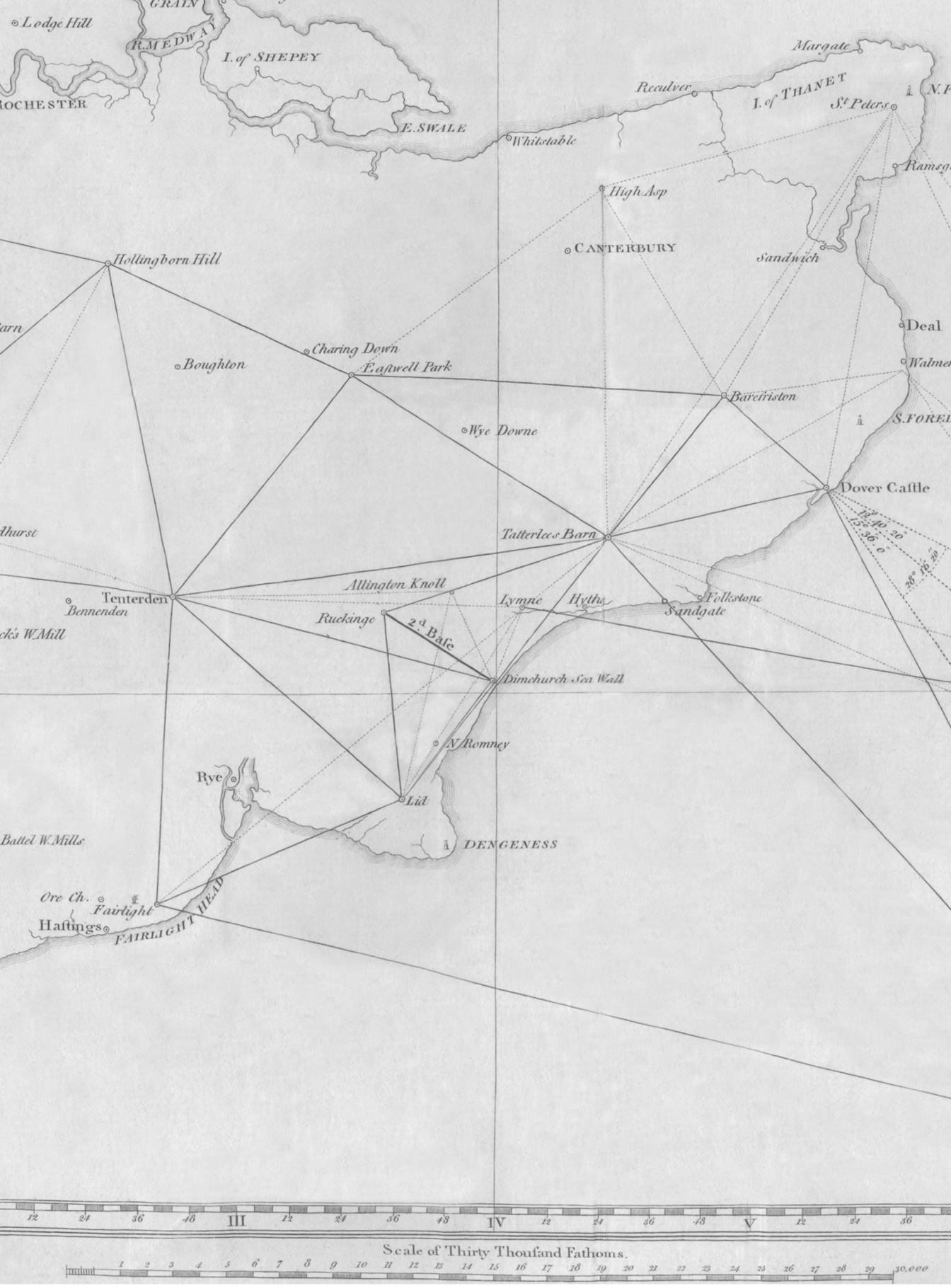
ervatories *of* GREENWICH *and* PARIS.

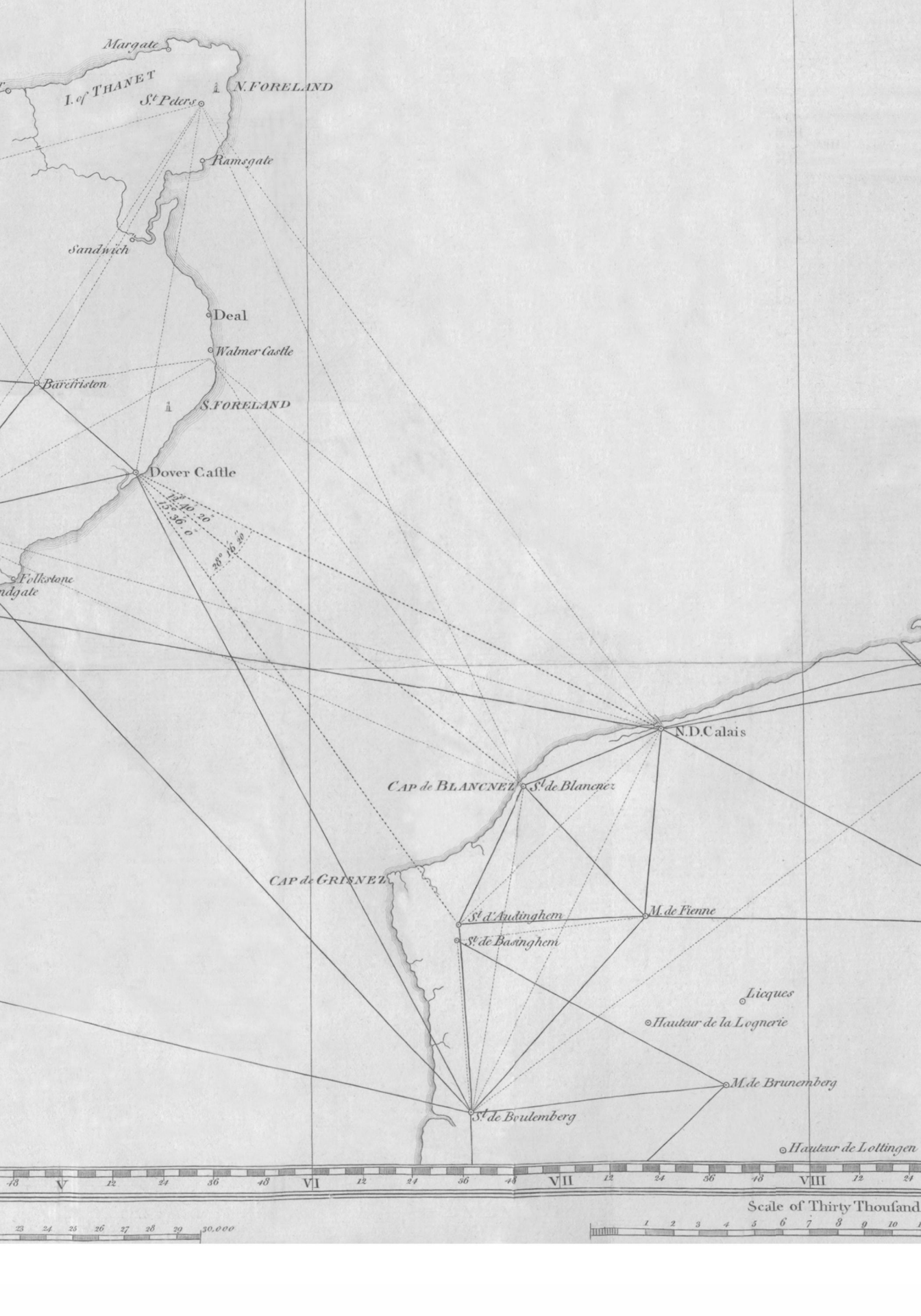
Philos. Trans. Vol. LXXVII. *Tab.* IX. *p.* 228.

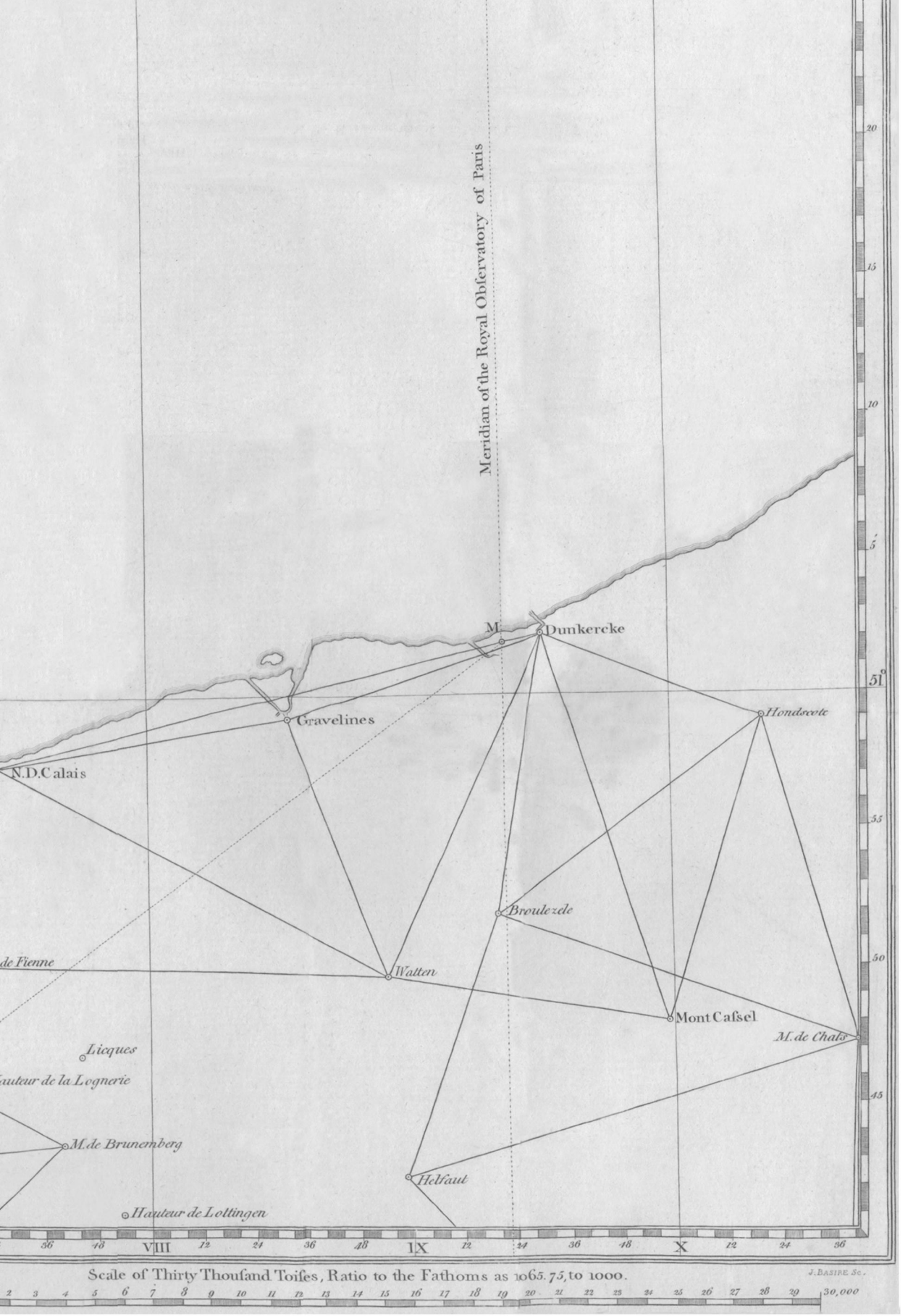



St. Ann's Hill
Norwood
Clarement Tower
Hundred Acres
Banstead
Bottle Hill
Leeth Hill Tower
Firedean
Hind Head
E. Grinstead
Meridian of the Royal Observatory of Greenwich
Lagham
Little Hampton
Brighthelmstone
Adur Riv.
SELSEY HARBOUR
ARUNDEL HAVEN
Scale of Thirty English Miles.


Norwood
Lodge Hill
GRAIN
R. MEDWAY
I. of S
ROCHESTER
Hundred Acres
Wellhill
Wrotham Hill
Bottle Hill
Sevenoakes W. Mill
Hollingborn Hill
Shingle Barn
Boughton
Firedean Tower
E. Grinstead
Brenchley
Goudhurst
Frant Ch.
Tenterden
Bennenden
Crowborough Beacon
Seacock's W. Mill
Royal Observatory of Greenwich
Meridian of the
Rye
Battel W. Mills
Ore Ch.
Fairlight
Hastings
FAIRLIGHT HEAD
Brighthelmstone
Adur Riv.
Newhaven
Seaford
Ouse Riv.
Cockmere Riv.
Langney Point
BEACHY HEAD
O
I M.
II
III


Lodge Hill
GRAIN
R. MEDWAY
I. of SHEPEY
ROCHESTER
E. SWALE
Whitstable
Reculver
Margate
I. of THANET
St Peters
N. F
Ramsg
High Asp
CANTERBURY
Sandwich
Hollingborn Hill
Deal
Walme
Charing Down
Boughton
Eastwell Park
Barrestone
S. FOREL
Wye Downe
Dover Castle
Talterlees Barn
Allington Knoll
Tenterden
Bennenden
Lymne
Hythe
Folkstone
Sandgate
Ruckinge
2d Base
Dimchurch Sea Wall
N. Romney
Rye
Lid
DENGENESS
Ore Ch.
Fairlight
Hastings
FAIRLIGHT HEAD
12 24 36 48 III 12 24 36 48 IV 12 24 36 48 V 12 24 36
Scale of Thirty Thousand Fathoms.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30,000


Margate
I. of THANET
S.t Peters
N. FORELAND
Ramsgate
Sandwich
Deal
Walmer Castle
Barrestone
S. FORELAND
Dover Castle
12° 40' 30"
13° 36' 0"
20° 16' 30"
Folkstone
ndgate
N.D. Calais
CAP de BLANCNEZ
S.t de Blancnez
CAP de GRISNEZ
S.t d'Audinghem
M. de Fienne
S.t de Basinghem
Licques
Hauteur de la Logneric
M. de Brunemberg
S.t de Boulemberg
Hauteur de Lottingen
48 V 12 24 36 48 VI 12 24 36 48 VII 12 24 36 48 VIII 12 24
Scale of Thirty Thousand
23 24 25 26 27 28 29 30.000
1 2 3 4 5 6 7 8 9 10


Meridian of the Royal Observatory of Paris
M.
Dunkercke
Gravelines
N.D.Calais
Hondscote
Broulezde
Watten
Mont Cafsel
M. de Chats
de Fienne
Licques
auteur de la Lognerie
M. de Brunemberg
Helfaut
Hauteur de Lottingen
20
15
10
5'
51°
55
50
45
36 48 VIII 12 24 36 48 IX 12 24 36 48 X 12 24 36
Scale of Thirty Thousand Toises, Ratio to the Fathoms as 1065.75, to 1000.
J. BASIRE Sc.
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30,000

APPENDIX.

A Supplement to Major-General Roy's *Account of the Mode propoſed to be followed in determining the relative Situation of the Royal Obſervatories of* Greenwich *and* Paris. See p. 188.

Read Nov. 8, 1787.

IN the account of the propoſed trigonometrical operation for determining the difference between the meridians of the Royal Obſervatories of Greenwich and Paris, I have, at p. 221. and 222. had occaſion to remark on an inconſiſtency found in the ſum of the three equations, as ſtated by M. BOUGUER, for obtaining the lengths of degrees of great circles perpendicular to the meridian, above their correſponding degrees of latitude, without having been aware of the true ſource of the error, for which I am indebted to the inveſtigations of the Aſtronomer Royal; who, having found it out, obligingly communicated the ſame to me, about the time of the annual receſs of the Society in the end of June laſt.

At p. 289. and again at p. 313. and 314. of M. BOUGUER's Book, the ſubtractive branch of the equation, or the part of DG the gravicentric arc, anſwering to the difference between the *radii* of curvature at the equator and given latitude, has erroneouſly been expreſſed in words $\frac{3}{4}$ths inſtead of $\frac{4}{5}$ths, which the algebraic *formula* juſtly gives for it, and according to which M. BOUGUER's table has been accurately computed. Not ſuſpecting any thing of this ſort, no intima-

tion of it appearing among the *errata*, and no notice having been hitherto taken, as far as I know, of ſuch a miſtake exiſting in that juſtly celebrated work, now ſo many years in circulation throughout the world; inſtead therefore of $\frac{4}{1\,5}$ths, or $\frac{8\,0}{3\,0\,0}$ parts of the third proportional, the laſt additive member of the equation, I ſubſtituted another (with a certain modification, however, as ſtated in the before-mentioned pages) amounting only to $\frac{8\,0}{3\,7\,0}$ parts of the third proportional, being the higheſt that would apply to the whole quadrant, without producing abſurd reſults. Thus I obtained approximate degrees of great circles and of longitude, differing but little from thoſe of M. BOUGUER, and compenſating in a great meaſure, although not altogether, for the then undiſcovered cauſe of the miſtake of $\frac{1}{2\,0}$th part of the arc DG; for $\frac{4}{5} - \frac{3}{4} = \frac{1}{2\,0}$.

In this ſtate of the caſe, I have judged it incumbent on me to annex a ſupplementary table, where the degrees of great circles and of longitude are accurately computed by the corrected ſubtractive branch $\frac{4}{5}$ths of DG inſtead of $\frac{3}{4}$ths, as it now ſtands in the original table. From inſpection it will appear, that the maximum of correction amounts nearly to $5\frac{1}{2}$ fathoms at the 70th degree of latitude, diminiſhing gradually from thence to the pole on one ſide, and the equator on the other, where it vaniſhes. The maximum of correction for the degrees of longitude, amounting to about $2\frac{1}{3}$ fathoms, is applicable between the 58th and 59th degree of latitude, where M. BOUGUER's degree of the meridian becomes equal to his degree of longitude on the equator. From this point, it diminiſhes gradually to the pole on one ſide, and the equator on the other, where it in like manner diſappears.

With regard to degrees of great circles ſituated obliquely to the meridian, it is ſufficiently obvious, that they are ſo little affected as to render it of but ſmall importance whether they

are corrected or not; but for such as are scrupulous to fractional parts of fathoms, these may satisfy themselves with great facility and exactness, by attending to and proportioning by the common tabular differences, as in the following example of the application of the correction to oblique degrees, in the latitude of Greenwich 51° 28′ 40″.

	Obliquity.	Original tabular difference.	Supp. correction.	Corrected difference.	Corrected degree.
	° ′	Fath.	Fath.	Fath.	Fath.
Application of the correction to the degrees of great circles, situated obliquely to the meridian, in the latitude of Greenwich.	45 0	204.45	−1.65	+ 202.80	61070.20
	33 45 / 56 15	78.24	−0.63	− / + 77.61	60992.63 / 61147.85
	22 30 / 67 30	66.33	−0.54	− / + 65.79	60926.84 / 61213.64
	11 15 / 78 45	44.32	−0.36	− / + 43.96	60882.88 / 61257.60
	0 0 / 90 0	15.56	−0.12	− / + 15.44	60867.44 / 61273.04

Here it is to observed, that half of the correction is constantly to be applied at the 45th degree of obliquity; and since the differences between the terms in the progression equally removed on either side from 45°, are always equal to each other, it follows, that the corrected differences are to be applied with the contrary sign, those between 45° and the meridian being in diminution, and these between 45° and the east or west points being in augmentation of the length, till, in the first case, the degree becomes equal to that of latitude; and in the last to that of a great circle perpendicular to the meridian.

The Table of Comparison, p. 227. is no where affected by the alteration which has been the subject of this discussion, except in the two last lines from the bottom, as adverted to among the *errata* subjoined to this supplement.

This intimation of M. Bouguer's mistake in expressing his formula in words, was accompanied with the conversion of

that

that formula by Dr. MASKELYNE into the following, adapted to natural ſines, $\frac{a \times 11 + 8 \times \text{cof. } 2 \text{ lat} - 3 \text{ cof. } 4 \text{ lat.}}{30}$. a is the exceſs of the radius of curvature at the pole above that at the equator, and the ſign of either term is only to be changed when the doubled or quadrupled latitude become greater than 90°, and leſs than 270°.

I embrace this opportunity of mentioning another circumſtance, wholly unknown to me at the time my Paper was compoſed. From what has been there ſaid, at p. 216. and ſo on to p. 220. it will probably be inferred, that I conſidered the propoſed mode of determining the differences of longitude by the obſervations of the pole ſtar, made with a very accurate inſtrument, rather as new, not knowing that the ſame idea, or one nearly the ſame, had before occurred to the Rev. Mr. MICHELL, and been treated on by him in his very ingenious Paper in the Philoſophical Tranſactions, Vol. LVI. for the year 1766. That I muſt have read that valuable performance about the time of its publication is not to be doubted; but in the lapſe of ſo many years, every trace of it had gone from my remembrance, otherwiſe I would have moſt certainly referred to it in the proper place, and with the attention that it ſo well deſerves. However, without entering here into particulars, it will obviouſly appear, that the one has not been borrowed from the other.

E R R A T A.

In p. 195. l. 27. for between Gravelines and Calais read between Watten and Gravelines. And in l. 28. for 56° 42′ 0″ read 46° 52′ 0″.

In p. 197. in the diſtance of the parallel of Rodés from that of Dunkirk, for 6° 50′ 51″ 14‴ read 6° 40′ 51″ 14‴.

In the laſt line of the note at the bottom of p. 217. inſtead of 1° 49′ 8″.8, read 1° 49′ 48″.8.

In p. 221. line 6. from the top, inſtead of $\frac{7}{15}$ths, read $\frac{8}{15}$ths.

In the Table of Compariſon, p. 227. the laſt line but one of the laſt column but one, for 44373.5 read 44372.0. In the next line below, for 38164.0, as formerly corrected, read 38162.0. And in the right-hand column, laſt line but one from the bottom, for + 19.1, read + 17.6.

Places.	Latitudes.	Sum of the 3 equat. ⅘ths of DG being subtractive.	Supplementary correction for deg. of great circles.	Degrees of great circles perpendicular to the meridian corrected.	Diff.	Supplementary correction for deg. of long.	Degrees of longitude corrected.	Diff.
Equator	° ′ ″ 0 0 0	545.12	±0 00	61029.62	2.02	0.00	61029.62	230.24
	5 – –	547.081	+0.07	61031.64	6.38	+0.04	60799.38	688.66
	10 – –	552.595	+0.82	61038.02	9.80	+0.86	60110.72	1143.04
	15 – –	558.739	−0.90	61047.82	16.48	−0.85	58967.68	1586.02
	20 – –	565.811	−0.70	61064.30	20.52	−0.67	57381.66	2020.01
	25 – –	567.715	−0.83	61084.82	25.72	−0.74	55361.65	2438.38
	30 – –	562.156	−0.99	61110.54	30.88	−0.86	52923.27	2839.16
	35 – –	546.285	−1.25	61141.42	35.71	−1.02	50084.11	3219.70
	40 – –	518.144	−1.73	61177.13	7.68	−1.33	46864.41	687.63
	41 – –	510.955	−1.78	61184.81	7.83	−1.34	46176.78	701.78
	42 – –	503.235	−1.90	61192.64	7.93	−1.40	45475.00	715.74
	43 – –	494.946	−2.07	61200.57	4.36	−1.51	44759.26	387.29
S. of France	43 32 –	490.392	−2.11	61204.93	3.81	−1.53	44371.97	342.08
	44 – –	486.244	−2.16	61208.74	8.26	−1.54	44029.89	742.97
	45 – –	476.984	−2.30	61217.00	8.39	−1.66	43286.92	756.18
	46 – –	467.216	−2.42	61225.39	8.50	−1.67	42530.74	769.34
	47 – –	456.972	−2.58	61233.89	8.60	−1.77	41761.40	782.27
	48 – –	446.252	−2.75	61242.49	7.28	−1.83	40979.23	664.59
Paris	48 50 14	436.936	−2.83	61249.77	1.41	−1.87	40314.64	130.25
	49 – –	435.084	−2.85	61251.18	8.78	−1.87	40184.39	807.24
	50 – –	423.488	−3.03	61259.96	0.73	−1.94	39377.15	67.83
	50 5 –	422.504	−3.06	61260.69	0.74	−1.97	39309.32	67.90
	50 10 –	421.508	−3.06	61261.43	0.73	−1.97	39241.42	68.00
	50 15 –	420.523	−3.07	61262.16	0.74	−1.95	39173.42	68.09
	50 20 –	419.534	−3.11	61262.90	0.74	−1.99	39105.33	68.14
	50 25 –	418.526	−3.13	61263.64	0.73	−1.99	39037.19	68.26
	50 30 –	417.531	−3.14	61264.37	0.74	−2.01	38968.93	68.33
	50 35 –	416.528	−3.15	61265.11	0.73	−2.02	38900.60	68.41
	50 40 –	415.524	−3.16	61265.84	0.75	−2.03	38832.19	68.50
	50 45 –	414.515	−3.20	61266.59	0.73	−2.03	38763.69	68.58
	50 50 –	413.500	−3.21	61267.32	0.74	−2.04	38695.11	68.65
	50 55 –	412.491	−3.21	61268.06	0.74	−2.02	38626.46	68.75
	51 0 0	411.477	−3.22	61268.80		−2.01	38557.71	

Places.	Latitudes.	Sum of the 3 equat. $\frac{4}{3}$ths of DG being subtractive.	Supplementary correction for deg. of great circles.	Degrees of great circles perpendicular to the meridian corrected.	Diff.	Supplementary correction for deg. of long.	Degrees of longitude corrected.	Diff.
	° ′ ″							
	51 0 0	411.477	−3.22	61268.80	0.74	−2.01	38557.71	68.83
	51 5 –	410.459	−3.22	61269.54	0.74	−2.02	38488.88	68.91
	51 10 –	409.437	−3.25	61270.28	0.74	−2.03	38419.97	69.00
	51 15 –	408.408	−3.29	61271.02	0.74	−2.06	38350.97	69.07
	51 20 –	407.387	−3.29	61271.76	0.74	−2.07	38281.90	69.17
	51 25 –	406.357	−3.30	61272.50	0.54	−2.09	38212.73	50.77
Greenwich	51 28 40	405.601	−3.30	61273.04	0.20	−2.04	38161.96	18.48
	51 30 –	405.320	−3.31	61273.24	0.74	−2.09	38143.48	69.31
	51 35 –	404.291	−3.32	61273.98	0.74	−2.07	38074.17	69.41
	51 40 –	403.253	−3.32	61274.72	0.74	−2.07	38004.76	69.48
	51 45 –	402.213	−3.37	61275.46	0.75	−2.06	37935.28	69.59
	51 50 –	401.168	−3.37	61276.21	0.74	−2.08	37865.69	69.68
	51 55 –	400.128	−3.38	61276.95	0.74	−2.11	37796.01	69.70
	52 0 0	399 080	−3.40	61277.69	8.94	−2.09	37726.31	843.09
	53 – –	386.325	−3.35	61286.63	8.95	−2.13	36883.22	854.59
	54 – –	373.232	−3.73	61295.58	8.97	−2.20	36028.63	865.79
	55 – –	359.851	−3.90	61304.55	8.97	−2.24	35162.84	876.75
	56 – –	346.187	−4.07	61313.52	8.94	−2.27	34286.09	887.48
	57 – –	332.301	−4.23	61322.46	8.91	−2.30	33398.61	897.94
	58 – –	318.213	−4.39	61331.37	6.33	−2.33	32500.67	646.60
	58 42 47.4	308.075	−4.51	61337.70	2.53	−2.35	31854.07	261.52
	59 – –	303.963	−4.55	61340.23	8.80	−2.35	31592.55	918.03
	60 – –	289.569	−4.69	61349.03	42.39	−2.34	30674.52	4729.38
	65 – –	217.320	−5.28	61391.42	10.69	−2.23	25945.14	1297.41
Lapland	66 20 –	198.361	−5.39	61402.11	27.58	−2.16	24647.73	3637.54
	70 – –	148.229	−5.47	61429.69	32.38	−1.87	21010.19	5102.64
	75 – –	87.821	−4.89	61462.07	25.39	−1.27	15907.55	5230.44
	80 – –	41.569	−3.81	61487.46	13.98	−0.74	10677.11	5316.91
	85 – –	10.309	−2.16	61501.44	5.16	−0.20	5360.20	5360.20
Pole	90 0 0	0.000	∓0.00	61506.60		∓0.00	0000.00	

N. B. The degree of the meridian, whose center answers to the latitude of 43° 32′, is in length 60714.54 fathoms.